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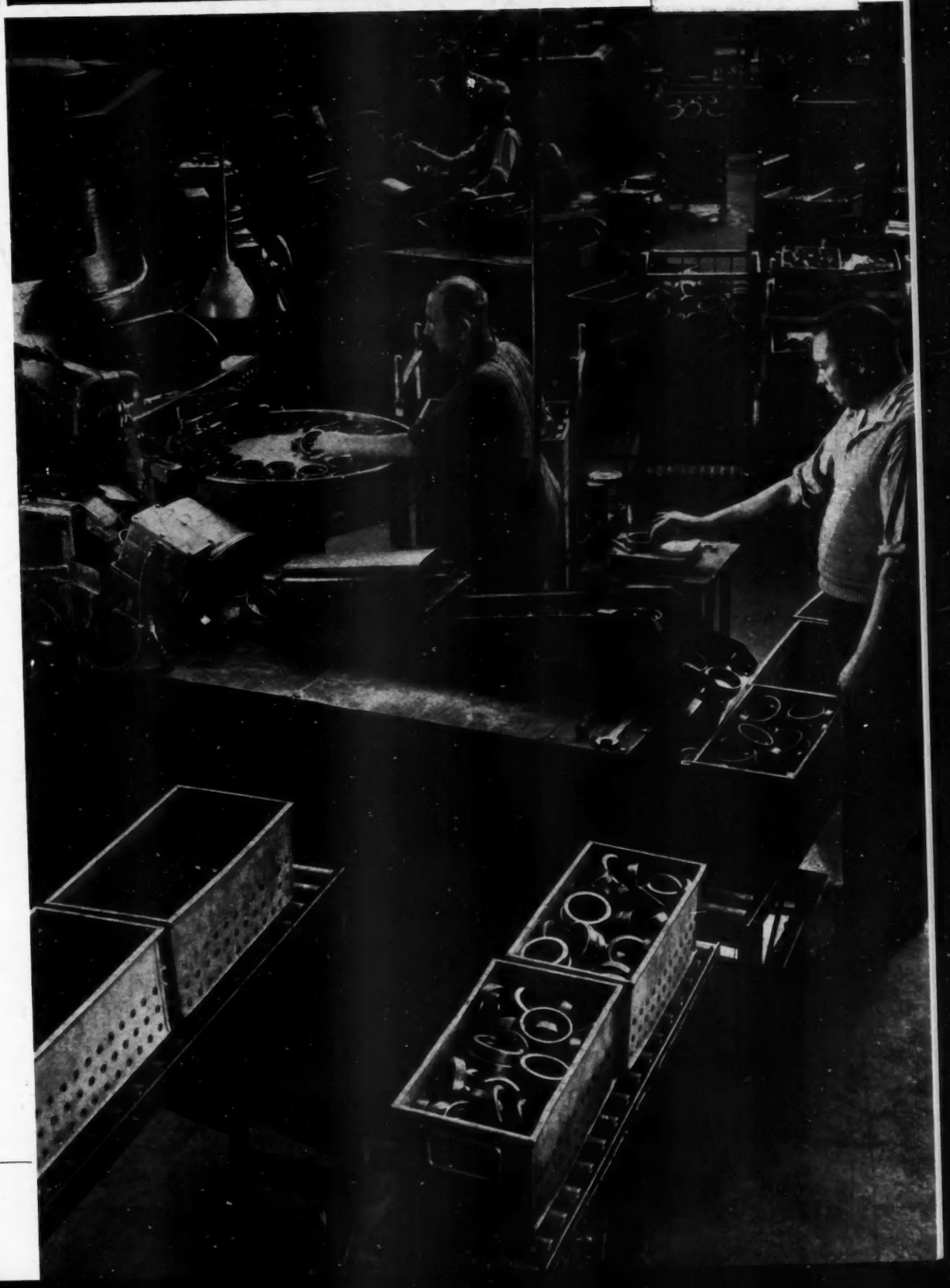

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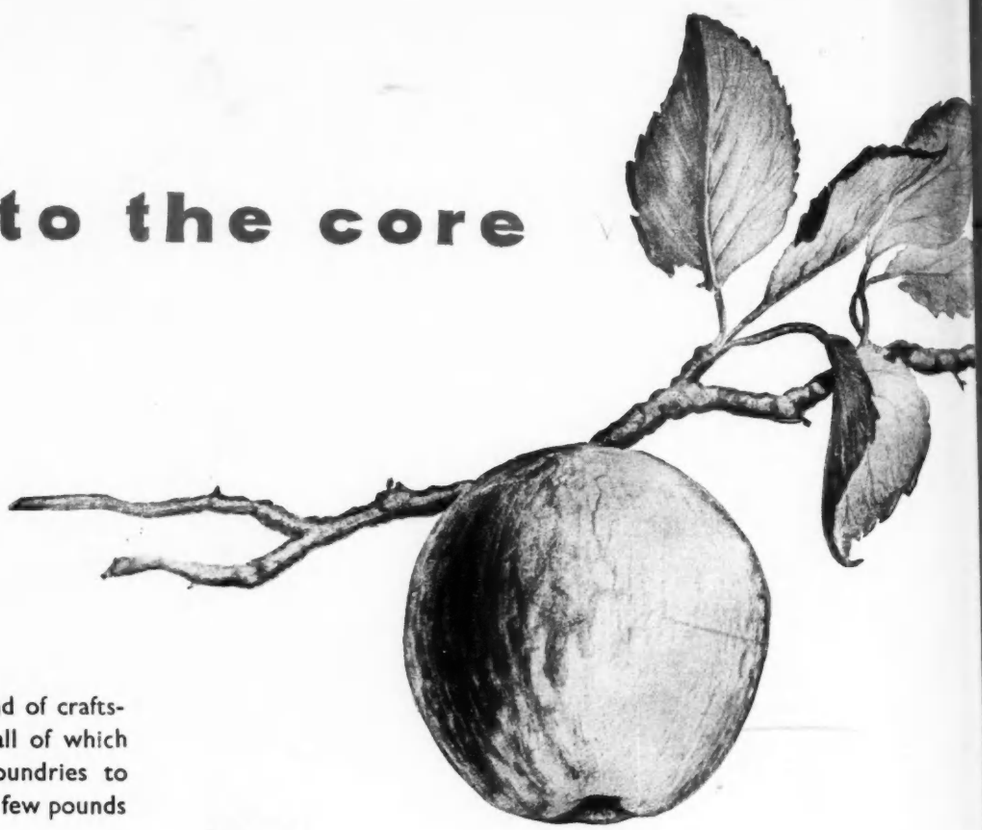

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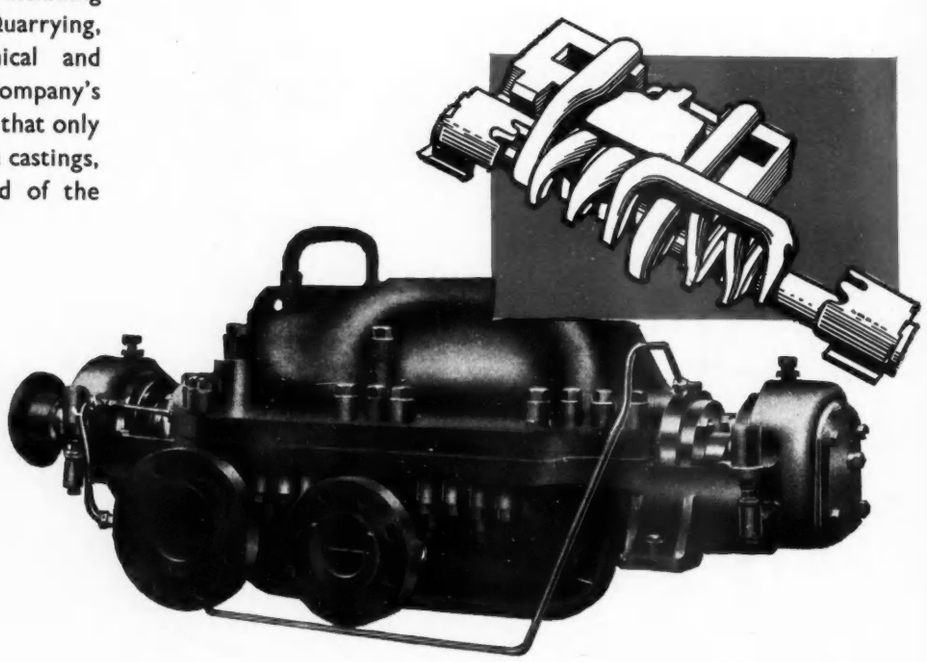

Osborn castings are used in this *Hayward Tyler—Byron Jackson six-stage 'Multiplex' pump.* Inset illustrates core used for casting the upper half of casing.

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Get On or Go Under

LAST week the Restrictive Practices Court gave its first judgment on a price-fixing agreement. The Court's findings were adverse and the judgment is of wide significance to British industry. To some extent the case was a special one but it has indicated the criteria which the Restrictive Practices Court will adopt in examining price-fixing agreements in the future.

The Court's judgment was given against the price-fixing agreements operated by the Yarn Spinners Association in the cotton textile industry. This particular scheme, which fixes minimum prices for members, has been particularly successful in maintaining prices, profits and employment in that particular section of the Lancashire cotton industry. Its operation has been the envy of other sections of the cotton textile industry, indeed of the whole profession of price-fixers, and it has for long stood as a model of what can be achieved in the way of remunerative and stable prices by solidarity among companies in an industry and by agreement as to the object in view between employers and the trade unions.

The Court is satisfied that the prices charged were higher than could be justified in the public interest. The customer has paid too much for his yarn. The judges, of whom there were three hearing the case, have been impressed by the fact that in their view the price of yarn has raised the price of cloth and so reduced the competitive power of the industry in export markets.

The argument has clearly been given careful consideration by the Court that the withdrawal of the price agreement will reduce employment in the industry at a time when it is already operating under difficult conditions. The judges have indicated, however, that they will not allow stability of employment to influence their views where an industry is clearly operating under market conditions which call for contraction. They consider that the price fixed for yarn has been high enough to maintain inefficient producers in the industry and to preserve a larger capacity overall than can be justified by economic conditions. They consider the industry would have been wiser to adjust its capacity gradually rather than run the risk which has now been realised, of a quick and painful adjustment if the flood gates are suddenly opened. The Court does not feel justified in interfering with the transfer of labour from the cotton industry which general economic conditions seem to demand.

At this point, of course, the situation becomes a political rather than a legal one, but the Court has shown quite clearly that in matters of price-fixing it will not hesitate to take into consideration long-term economic trends which have political implications if this is necessary for a sound legal judgment. Their courage is to be commended even though it will pose some awkward problems for politicians in both main parties.

The Yarn Spinners' agreement had a large number of provisions but it stood or fell on the validity of the minimum prices. This price was calculated on a high hypothetical average cost, and clearly in the Court's opinion it erred on the high side. The purpose of the agreement, according to the association, was to protect spinners against short periods of bad trade and even in longer slumps when price cutting might become prevalent, as was the case in the 1930's before the price-fixing agreement was introduced. Under the law as it is the Court is forced to condemn any price-fixing agreement as contrary to the public interest unless one or more of seven conditions are fulfilled. One of these is that the price-fixing arrangement must benefit the public as consumers. It is quite possible that under certain circumstances this could be so and the Court in this instance has not been condemning minimum price schemes in principle. The Court did find, however, that in this case the price was fixed too high for customers. The spinners had a significant point in that although the agreement might not be justified in law as beneficial to customers, it was nevertheless beneficial in maintaining employment in a certain area. The Court, however, has not found it possible to accept this argument since, in its view, a gradual adjustment of price and capacity without a price-fixing agreement would have brought about a smaller and presumably more efficient spinning industry.

Anyone who thought that the Restrictive Practices Act was a fairly harmless sop to a fashionable but passing trend in liberal economic thought has made a grave mistake. This Act, and the Court which it creates, have teeth. Many price-fixing agreements in many industries will be quietly put on the fire after this legal decision. Thirty years ago, such an Act, such a Court and such a judgment would have been inconceivable. In those days all was retrenchment, rationalisation and "united we stand" against economic blizzard. Today we all believe—or are supposed to—in higher productivity and expansion. We had better believe it because the law has now enshrined this philosophy in a major precedent.

Cover Picture.—*Outer rings for ball bearing races are shown being fed into a surface grinder. As the rings leave the machine they are demagnetised and washed before being submitted to a sample inspection. The rings then move along the roller conveyor towards the next operation.*

(*Nurnberg photograph for* ENGINEERING)

Plain Words

I have just come across a scheme for saving the nation ten million pounds a year. There is only one snag; we're far too conservative a people to accept it. It's curious how we reject the best technical methods, the most convenient tools, the strongest, neatest, most desirable products, merely because we are not accustomed to them. It is not the manufacturers who are to blame; it is ourselves, the discriminating public. We would think twice before having aluminium roofs to our houses, or prefabricated walls; we insist on tiles, usually without insulation, and red bricks laid laboriously one upon another—subject to the weather—by men whose time is valuable. Three hundred thousand houses a year, a thousand pounds a house and a 4 per cent saving by factory methods, modules and prefabrication: that's over ten million pounds.

"Prefabrication?" you say. "Ghastly! Those horrid little huts." True the word has acquired a distasteful implication; but is the principle at fault? We have never as a nation really assimilated engineering to our daily life; it is something that goes on in factories and on remote and desolate sites. We should never dream of applying it in our homes—except when it is disguised by a glossy anonymous cabinet.

Who would choose a house built so that its shape and structure were entirely determined by its convenience for living in, the best materials to hand and the logic of their form and mathematics? Very few of us would care to have our homes designed by Walter Gropius, Alvar Aalto or Mies van der Rohe—or built by a consortium of engineering companies.

We spend so much money laying bricks that we cannot afford a properly equipped and laid out kitchen: washing day becomes a marathon point-to-point and cooking calls for a juggler's virtuosity. Our pipes freeze up in winter; our heat goes up the chimney; our bedrooms make us shiver; and our ceilings crack. I understand a group of British firms once banded together to design a sensible house, using modern methods and materials, but no-one cared to live in it because it didn't look right. But the time is coming when we shall have to take notice of the Building Research Station crying in the wilderness of Watford, or find we can no longer keep pace with even the need to replace existing houses.

We can't afford to admire our predecessors to the point of imitation. What self-respecting Elizabethan would have built his house of wattle?

CAPRICORN

Weekly Survey

Advising the Chancellor

The various organisations which have submitted memoranda to the Chancellor of the Exchequer in the form of advice as to what he should do in his April Budget have this year had a common theme. They are all in favour of reduced taxation. It is a persistent popular panacea, but this year there is a degree of sophistication and logic in the arguments.

The transition from recession to recovery seems to have begun, and everyone is concerned to speed up the process, thereby restoring prosperity and reducing unemployment. With the level of capital investment already high so far as the public sector is concerned, there is considerable danger that the economy can pass from deflation to inflation very rapidly—as the Amercians have done. To provide a stimulus to private investment without raising prices is widely recognised to be the target, and lower taxation is the favourite prescription for achieving it, though the Americans themselves carefully resisted the temptation.

The latest advice for the Chancellor of the Exchequer comes from the Federation of British Industries. The FBI consider that economic policy in the forthcoming year should be expansion in all sectors of the economy, short of the revival of inflation, and lower costs to meet competition in export markets. It therefore proposes that investment allowances should be restored to the rate of 15 per cent for buildings and 30 per cent for plant and machinery. It would remove the purchase tax on materials and equipment used in production processes, such as the tax on commercial vehicle chassis and commercial stationery. It would reduce the profits tax to 7½ per cent and extend surtax earned income relief. Finally, it recommends a reduction in the standard rate of income tax by 6*d* in the £ with accompanying cuts in the reduced rates of payment. The FBI is, therefore, backing the Budget favourite which is a reduction in income tax, and this is no bad bet in what is likely to be an election year.

The Taxman Cometh

Do you work out your own income tax position or do you go to see that very good accountant that somebody or other recommended to you? Whichever method you follow it is just as well to understand exactly what you are paying and why. This complicated task is made very much easier by a new book published by Putnam at 9*s* 6*d*. It is called *A Simple Guide for the Taxpayer* and is written by Mr. John Wood. Reading through this very readable little book makes the tax system appear more logical and rather less vindictive than before. The reason for Schedule A, the importance of submitting maintenance claims and the different treatment for tax purposes of repairs or replacements and improvements, are all carefully explained.

What tax does to small savings is another interesting topic which becomes clear from Mr. Wood's book. The advantage of National Savings to the sur-tax payer and their relative unprofitability for the man paying no tax at all are illustrated in a table which assesses the relative value to the investor of the principal types of small saving. The tax problems of the self-employed and the reasons leading the Inland Revenue to issue "surtax directions" are also examined. Many procedures with familiar names are not at all clearly understood. For instance, what is involved in a husband "settling" property on his wife, and just who benefits from this. Again what is a "letter of wishes" and who has to take notice of it? And is a dividend ever really "free of tax"? Those who know the answers to all these questions will find Mr. Wood's guide too simple. But for the rest, with the season of pre-budget tax reduction suggestions approaching, it will be invaluable in making clear just what it is the Chancellor is being asked to do.

A Tale of Two Tunnels

Last autumn two teams of engineers started to burrow their way northwards through the Alps. In about three years one or the other will have completed its task and made the first motor road under the Alps a reality.

One tunnel runs from Chamonix in France to Entrèves in Italy, passing under Mont Blanc. The other links Bourg St. Pierre in Switzerland with St. Rémy in Italy, via the Great St. Bernard route. Although longer the Mont Blanc tunnel presents fewer engineering problems. It is at an altitude of 1,200 to 1,380 metres, compared with 1,875 to 1,905 metres on the St Bernard. Also the approaches, especially at the Italian end are much easier. The St. Bernard tunnel will require long stretches of roofed-in roadway so that it can be used in the winter time. It also involves an extensive bridge over a ravine on the Italian side. A hydro-electric station is being built as part of the scheme at the Swiss end. The money for these tunnels is coming partly from central and local government bodies and partly from industry. Fiat has a stake in the St. Bernard tunnel which serves Turin by way of the Val d'Aosta.

The big advantage of these Alpine tunnels is that they will make all-the-year-round road traffic a possibility. If, as is expected, they should prove to be only the first of several such schemes it may be that in ten years time the only winter-time motorists travelling over the passes will be contestants in the Monte Carlo Rally.

No Auto Stop

When the elections almost cleared the French Communists out of Parliament it was widely supposed that they would pop up in the factories. Instead of delaying tactics on the floor of the Assembly they would organise go-slow moves on the shop floor. The nationalised industries were clearly targets for this kind of activity and of these one of the most vulnerable was the Régie Renault.

With France building up a big export market for cars, delays and stoppages at Billancourt could be disastrous. However, the signing of a new wage agreement between the Renault management and the four principal non-Communist trade unions seems to push this threat into the background. A few years ago Renault was one of the battlegrounds of the class war. Then in September, 1955, the now famous wage agreement was signed, under which workers received an automatic annual increase of 4 per cent and a bonus from profits. In addition the official social security scheme as augmented, by arrangements giving retirement pensions, family holidays and sickness benefits.

When the 1955 agreement was discussed the Communist-led CGT did its best not to add its signature. Six months later they decided to make the best of both worlds and signed. As some 60 per cent of Renault's workers belong to the CGT it is clear that its directives are not always followed. Calls for strike action against the return of General de Gaulle and the referendum both failed. The new agreement continues the automatic annual increase of 4 per cent and adds to it an annual bonus in the region of £5. There are also guarantees against loss of earnings through short time. With the threat of a recession in the motor industry this has been a main cause of worry to the trade unions. The Renault

agreements are regarded as a model by other French concerns. The general working conditions and welfare arrangements they provide have gone a long way towards turning the Renault factories, especially Billancourt, from hot-beds of Communism into oases of high productivity in the French economy. For once the Communist hitch-hiker has been unable to succeed in his attempt at what the French call "auto stop."

London Midland Confidence

A welcome note of confidence can be detected in the railways' attitude to competition. The latest example comes from Mr. David Blee, general manager of the London Midland Region.

This region gets two-thirds of its business from rail traffic. At present it is in the red. It proposes to remedy this position by three means —quicker movement, a speed-up of handling and by the development of the door-to-door service. The speed-up in movement is to be achieved by running more express freight trains. (Those already in service are considered a success.) This is to be aided also by a greater use of diesel engines in the 2,500 h.p. and 1,160 to 1,250 h.p. classes.

Speed of handling is to be increased by reducing the number of freight terminals and marshalling yards and by their modernisation. Depots dealing with sundries are to be reduced from 170 to 48. Marshalling yards are to be reduced from 111 to 46 to eliminate or reduce the handling of wagons, and this alone is expected to help considerably in reducing damage to traffic in transit. The plan is based on the establishment of a limited number of main trunk yards, the provision of satellite yards feeding into the trunks and the need to reduce the handling of wagons as well as a reduction in staff. Parcels traffic is to be concentrated at six centres; depots are to be equipped with suitable transfer appliances to deal with container traffic; warehouse facilities are to be mechanised and private sidings are to be reduced in number. The door to door service is to be developed on its present basis of central systems of rail heads with delivery to customers' doors by railway motor vehicles. A study is being made to develop containers with a good payload and low tare weight.

Lighter Cranes But Safe

The steel companies of Britain taken together are in the forefront of industrial research. One estimate of the annual research budget is £2 million, but a writer in *Steel Review* believes that this figure covers barely half the total spent if the four main types of work, forward research, development, works control and "post-mortem" research are all taken into account. One of the major objects of steel research is the structure of cranes. For years it is probable that cranes have been built with a grossly exaggerated but rarely calculated safety factor. The plant engineering and energy division of the British Iron and Steel Research Association and several individual firms are now carrying out research which will result in an effective crane which has much less metal in its construction.

Continental manufacturers have given a lead in making lighter and cheaper cranes. Many of these are now in use in British works. The Steel Company of Wales is reported to be using cranes made on the Continent. Research is now being directed to a study of the point loading on crane wheels. This investigation calls for *in situ* readings of point stresses on wheels and rails and the co-ordination of multiple results electronically.

Another problem being investigated is the tendency for the heavy-duty electric motors used in cranes to burn out owing to the faster duty cycle. The conditions under which the operator works are also receiving attention. Questions of ventilation and protection from heat are of primary importance here, as is the arrangement of controls to obtain highest efficiency. The methods used go all the way from asking the driver what he thinks is the best lay-out, to ergonomic studies in which data obtained from electric recording equipment is fed into an electronic computer for analysis. With all this research British cranes should be pulling their weight in competition with European makers.

Creditable Exports

Although there was a slight decline in United Kingdom exports last year, there was a 7 per cent increase in commercial business covered by the Export Credits Guarantee Department. The actual figure was £521 million compared with a previous record of £485 million in 1957. In the department's view, this fresh record was established owing to improved facilities offered, both technically and in cost of cover.

There has been a significant increase in short-term policies over the year, from 4,326 to 4,465. On the other hand, new medium term business fell from a record figure in 1957 of £157 million to £76 million in 1958. The high level of 1957 was due in part, however, to the underwriting of one particularly large project.

From the engineering point of view, the biggest event of the year was the decision to extend longer term credit on aircraft exports. There are sections of the industry, and aircraft is only one of them, where exporters still feel at a disadvantage against competitors in export markets because of the payment terms offered. It is time that this problem was seen in a wider context. Shortage of finance, both for customers and suppliers, is a chronic problem today. Easy payment arrangements and special facilities for raising capital are now part of the negotiating equipment for deals not only between governments but also between governments and companies. In these matters, export credit facilities should march with the times.

French Aircraft Difficulties

One of the industries that would benefit most from a period of stable government is the French aircraft industry. Although it has produced some extremely efficient types, such as the Caravelle and the Mystère fighter and has a variety of advanced designs at the prototype stage, the industry has been kept going by subsidies and has therefore suffered from the unstable political set-up in post-war France. There are some 27 concerns in the French aircraft industry, employing around 100,000 workers. The main problem is the lack of markets.

The Caravelle jet airliner sells abroad for about 600 million francs. But the various subsidies paid at the different stages of production amount to 200 million francs on each airliner. Small-scale production cannot hope to recoup the big research and development charges involved. The Armagnac transport plane took over five years to develop but only 15 were in fact built. The majority of the firms in the industry are too small to meet foreign competition. The exceptions are Nord-Aviation and Sud-Aviation the two state-owned groups. A regrouping of the rest will one day be inevitable but so far it has been resisted.

The dependence on Government orders has seriously weakened the competitiveness of the industry. Another factor, as in Britain, has been the switch over from manned combat planes to missiles. The French have tried to make the change gradually but it is probably true to say that design staffs in the industry are now working almost entirely on missiles. The opening of the European Common Market may give the French aviation industry the outlets it has so far lacked. But the Italians and Germans are also seeking to develop their own industries so that the European skies are likely to be far from clear for the French aircraft makers.

Letters to the Editor

CLEAR THINKING NEEDED

Suggestions Schemes

SIR, I have read with interest in recent issues a number of letters discussing the latest booklet of the Industrial Welfare Society on suggestion schemes. The points of controversy appear to be the philosophy behind the statistics and the contents of the booklet.

When at the IWS Suggestion Schemes Conference at Brighton in November, 1958, I wrote on the blackboard the name of a very potent book *How to Lie with Statistics*, by Darrel Huff. The only reasons for wrong figures are either a desire for a particular result or lack of knowledge on the part of the assessor. I think the statistics were misleading.

I rather felt that the booklet itself was not so powerful as it might have been. Surely, the one and only purpose of a suggestion scheme is to increase productivity. It is surprising just how effective such schemes can be for that purpose, and surely this country needs a little more productivity. I ask only one question: are the IWS really doing the best that can be done in this field and are they the right people to do it? The word "Welfare" occupies a certain significance in the minds of most industrial people, and I am sure that suggestion schemes are in danger of becoming confused with welfare and that the IWS are in danger of being considered incompetent in the field of suggestion schemes; especially when it is remembered that the only real authority on suggestion schemes in this country, Mr. P. Clavell Blount, is not included in the IWS committee.

Isn't it about time we had an independent suggestion scheme group? After all, we have again been good enough to allow the Americans their ten-year lead.

Yours faithfully,
D. COWPER.

7 Vernon Road,
Birmingham, 16.
2 February, 1959.

SIR, I am sorry that Mr. William Durham appears to have read my letter in your issue of 23 January (page 99) with less care than I exercised in reading the Industrial Welfare Society's booklet *Successful Suggestion Schemes*. Neither I, nor Don Quixote, to whom Mr. Durham has likened me, ever built windmills; we just tilt at those which are idly beating the air.

Now that Mr. Durham has corrected his arithmetical error it is possible to comment on the factors on which he appears to have based his claim of an improvement of 11·8 per cent. The total number of suggestions awarded in the 1956 suggestion scheme survey is given as 34,857. In the 1958 survey, this total has risen to 38,958. This shows an increase of 4,101 suggestions, or 11·8 per cent. But the total number of eligible employees rose by 165,170. We have no data regarding the difference per cent between suggestions *accepted* and suggestions *rewarded*. Therefore, all these figures are valueless, unless *our* thinking is muddled.

The above does not seem to be significant evidence of the "upward trend" mentioned in the foreword of the booklet. This evidence seems to indicate no more than that if more people are eligible to make suggestions you get more suggestions.

Contrary to Mr. Durham's statement, I made no criticism that British/United States comparisons had no point; in fact, I made a comparison—of results, *not* figures; the figures are too disparate to make any useful comparison. For example:—

—	British	American
Suggestions received	126,446	1,692,704
Suggestions received per 100 employees	6	26·5
Awards—total	£157,174	$13,956,841

Continuing **Letters to the Editor**

Mr. Durham states that the booklet says the "ins" and "outs" were small firms; that is so, but, as I said, no details were, or are now, given so the assumption I made remains reasonable. The point is not of great importance; the whole survey is suspect in the aggregate because of the enormous differences in the component figures. For example, employees eligible vary, firm by firm, from 79,930 down to 88; suggestions rewarded per 100 employees from 39·7 to 0·11. Conclusions drawn from totals based on such components serve no useful *comparative* purpose. Throughout the survey there are not enough common factors, and far too many disparate ones for any pattern or trend to be traceable to a point which justifies "positive thinking" unless it be positively muddled.

If there is evidence of "an overall impression that the suggestion scheme movement is spreading," it is not in these figures. "Some firms have improved, some declined and others have scarcely changed" (pages 28 and 30). In a previous paragraph (page 28) analysis is made of eight firms whose schemes have terminated between surveys. Not very hopeful, but "a number [?] of new schemes have been started." I believe false hope to be the enemy of positive action and often the result of muddled thinking.

I prefer to face facts and to find the *facts* before I draw conclusions. I wish Mr. Durham had given the figures for which I asked. He refers to "vast majorities" and "a great many firms." Either he is guessing, or he has the figures on which this statement is based. He certainly must have the figures relating to the IWS Suggestion Schemes Group membership and attendance. Why is he so coy? In the meantime, as we have had allusions to classical authors, may I suggest that, like Mr. Micawber, the IWS are hopeful that something will turn up?

Mr. Durham concludes by saying that your readers might like to judge matters for themselves. Perhaps they can assess Mr. Durham's hopes against what I still consider to be suspect data. My hope is that Mr. Durham may be right in his conclusions, but I see no factual reason to support it.

We now come to Mr. Shepherd's letter. He wants, in his experience, a British equivalent of the American National Association of Suggestion Systems, operating on a full-time basis. Therefore he believes that the IWS should eventually either drop their other activities or drop suggestion schemes.

Yours faithfully,
M. H. BRADSHAW-JONES.

229 Brompton Road,
London, S.W.3.
30 January, 1959.

SIR, I would like to congratulate you on your excellent choice of title for this series of letters. A suggestion scheme is, pre-eminently, an instrument for encouraging clear thinking, as well as for dealing with the fruits thereof. The title you have used, therefore, could hardly be more apposite.

In their booklet on suggestion schemes, the Industrial Welfare Society refer to "the remarkable success of suggestion schemes in the United States." In his letter on page 131 of your issue of 30 January, the assistant director of the Society points out that "the rate of progress" of suggestion schemes in the United States "is so far ahead" of that in this country. The conclusion reached by the Society following their nation-wide survey of suggestion schemes in 1956, and stated in their report, was that "the vast majority of suggestion schemes now operating in this country are failures".

The remarks which I have quoted do not come from some obscure, ill-informed source. They are the pronouncements of one of the largest, most reputable and most influential organisations in British industry, which, "from its inception in 1918, has supported the growth of suggestion schemes"—to quote again from their booklet. I submit, with great respect, that we should be *most* unwise, and indeed failing in our duty, to remain indifferent to these pronouncements, unpalatable though they may be.

Using such information as is available, let us compare the overall national results and rates of progress in America and Britain. It has been estimated that there are now more than 4,000 suggestion schemes in operation in American industry, commerce and government departments. The value of the *direct* benefits obtained last year through these schemes is estimated to have been at least $250 million net. The value of the indirect and chain reaction benefits was probably twice as much. The number of suggestion schemes now in operation in Britain has been put at not more than 500, and according to the Industrial Welfare Society, "the vast majority" of them are failures. The value of the direct benefits obtained through these schemes is estimated not to have exceeded £2,000,000. Making ample allowance for differences in population and other factors which might account for the difference between American results and those in this country, it would seem that due to the inadequacy of British suggestion schemes we are losing potential benefits worth at least £18,000,000 net per annum, and possibly many times that amount.

According to the figures published by the Industrial Welfare Society, the number of suggestions adopted per 100 eligible employees in the United States in 1955 was 6·5. The number adopted in this country for that year was 1·78. For the year 1957, these figures are given as 6·8 and 1·84, respectively. Thus it would seem that the improvement in America was 4·6 per cent as against 3·4 per cent in this country. Since our position was so very bad as compared with that in America, the scope for improvement here was very much greater. One would have thought, therefore, that our *rate of progress* would have been better than in America.

The American results and rate of progress show what *can* be achieved, subject to doing the right thing, but as the Industrial Welfare Society's booklet points out, these good results are only a recent phenomenon. Before the Second World War the situation in America was similar to, and possibly worse than, what it is at present in this country. The question which naturally arises is—what caused the change in America?

Briefly, the answer is that, having found that the various industrial associations which were supporting the growth of suggestion schemes on a part-time basis could not do the work effectively, a few clear-thinking, far-seeing public-spirited business men got together and formed their National Association of Suggestion Systems (NASS). The sole purpose of this association was to promote the widest possible adoption and successful operation of suggestion schemes, and from the record it is clear that they have done a job of inestimable value to the nation, and one of which to be proud. The secretariat of this Association, incidentally, numbers no more than four people. From an original handful of about 20 members, NASS have grown to a membership of well over 1,200, and are still growing. This membership includes all Federal Government departments and such leading companies as Babcock & Wilcox, Bell Telephones, Boeing Airplane, Crucible Steel Company of America, Eastman Kodak, Ford Motors, General Electric and the General Motors Corporation.

Since it is obvious that our capacity to produce good ideas is at least as good as that of our American friends, since we were first in this field (the first formal suggestion scheme was started at the William Denny shipyard in Dumbarton in 1880), since a few of our suggestion schemes have produced results even better than most of those in America, and since we all agree that we can only hold our position in world competition by the discovery and employment of new and better ideas in every field of activity and at every level, from the lowest upwards, it may be wondered why we have fallen so far behind.

The answer, in my opinion, is that, generally speaking, we are not really very interested in the subject, and little has been done to make us so. While it is true that some individuals, in their private capacity, are genuinely enthusiastic about suggestion schemes and advocate their wider adoption, they all have inescapable demands on their time which make it impossible for them to do very much beyond give the matter lip-service. The result, as Mr. Shepherd indicates on page 132 of your issue of 30 January, is that the promotion and development of these schemes continues to receive only such part-time attention as the Industrial Welfare Society and similar organisations can spare from their other pre-occupations. While it may be argued that such occasional, casual attention is better than nothing, the fact that our progress continues to be negligible suggests that, due to a false impression of vital activity being given, this may well be a case of *better* being the enemy of *best*.

You, Sir, may very properly question my right to inflict my views upon your readership. I have no right—other than the fact that since the end of the war I have done everything possible, within the limit of my personal resources, both to promote the formation of a British equivalent of NASS and, in the absence of such an Association, to do myself the promotional work that needs to be done in this field. From the unquestionable evidence which is available for your inspection, I am satisfied that this not inconsiderable expenditure of time and money has not been wasted. For example, I think the Industrial Welfare Society will readily agree that the formation of the IWS Suggestion Schemes Group was due, at least in part, to my efforts over a long period of years to persuade them to do more in this field than they were doing—though let me hasten to add that I am not a member of their group.

And what of the future? After living with this problem for more than ten years it seems to me that unless a British equivalent of NASS is formed we shall simply continue in a state of "hopefulness." This certainly will not put us on competitive terms in a world which is daily becoming more competitive than ever. Surely we cannot afford to leave the situation as it is and rely on "hope."

In conclusion, let me thank you on behalf of myself and those who are collaborating with me in this matter, for having focused the attention of your important and highly influential readership both upon what is, in my submission, our nation's most precious possession—namely, the capacity of each and every one of us to think more usefully—and upon the need, if we are to survive, to do everything possible to use this talent to the full.

Yours faithfully,
P. CLAVELL BLOUNT.

The White Cottage, Station Road,
Thames Ditton, Surrey.
2 February, 1959.

CONTRACTING WAGES EXPANDED

The 250,000 operatives employed in the civil engineering contracting industry have been granted a wage increase of 1*d* an hour, The increase was agreed by the Civil Engineering Construction Conciliation Board in accordance with the industry's sliding scale agreement based on the Index of Actual Prices. A top grade labourer will now get 4*s* 4*d* an hour and the top grade craftsmen 4*s* 10½*d* an hour (in both cases London rates).

Plant and Equipment

DIRECT INJECTION DIESEL ENGINE

Agricultural Industrial and Marine Versions

DETAILS have now been released of the first direct injection diesel engine to be made by F. Perkins Limited, Peterborough. It will be made in three versions, for agricultural. industrial and marine applications; the first two are now in production and the third will follow shortly.

The 270 D is a four cylinder four-stroke engine with bore and stroke of 4·25 and 4·75 in respectively. The agricultural version develops 62 b.h.p. at the maximum governed speed of 2,000 r.p.m., with a maximum torque of 189 lb-ft (gross) at 1,000 r.p.m. Full performance curves are given in Figs. 2 and 3; the marine version has a maximum rating of 58 b.h.p. Engine capacity is 269·5 cu. in (4·42 litres). The dry weight of the bare tractor model is 680 lb.

Cylinder block and crankcase are a single high duty alloy iron casting with wet cast iron liners. The head is also high duty cast iron and carries the rocker gear which is covered by an aluminium housing. Inlet valves are of 1 per cent chromium steel and exhaust valves of silicon chromium steel. The combustion chamber is toroidal in shape and is formed in the piston crown; swirl is imparted by the shape of the inlet ports without valve masking. The injector is of the multihole type. The crankshaft is a chrome-molybdenum steel forging, heat treated and with the main and big-end journals induction hardened. The design allows a torque up to 150 lb-ft to be taken from the front end. The shaft is supported in three main bearings of the thin-wall steel-backed copper-lead type, each half being located by tabs and slots. The camshaft, which is geardriven from the front end of the crankshaft, is of high duty cast iron with chilled cams, and is so placed that a power take-off can be fitted (through an opening in the timing case) for a maximum of 35 lb-ft (continuous) or 40 lb-ft momentarily.

The distributor fuel pump is mounted on the timing case and driven from the crankshaft. A mechanical governor is incorporated in the pump. Above it is a diaphragm lift pump fitted for hand priming. There is also provision for a fuel filter of the paper element type. Cold starting is assisted by the Thermostart heater fitted in the intake manifold, and decompression gear can be fitted for use when hand starting is required. A 12 V solenoid operated starter can also be fitted.

The pistons are high silicon aluminium alloy with three compression rings and one scraper above the gudgeon pin, and one scraper below. The pin is fully floating and is located by Circlips. Lead-bronze lined steel-backed wrapped little end bushes are used, and the big end bearings are thin-wall steel-backed copper-lead.

Lubricating oil is supplied by a gear pump driven through spiral gears from the camshaft. The oil is fed through a filter to a main gallery in the crankcase and thence to the main bearings. Drillings in the crankshaft lead to the big ends, and a supply is taken to the camshaft centre bearing where it is metered to the rockers and valve gear. Another supply leads to the timing idler gear hub which meters it to the timing gears generally. The cylinder bores, little-end bushes, and gudgeon pins rely on splash lubrication. The filter incorporates a by-pass and there is a pressure relief valve in the body of the pump.

Cooling in the agricultural and industrial types is obtained by a water circulating pump fitted to the front of the cylinder block and driven from the crankshaft. A pressed-steel fan can be fitted to the water pump pulley. A thermostat and by-pass are fitted to the outlet. In the marine version the pump is of the rubber impeller type mounted on the starboard side of the timing case and gear driven. The marine engine can be arranged for three alternative types of cooling and a water-cooled oil cooler can also be fitted.

Fig. 1 The latest addition to the range made by Perkins is the 270 D direct injection engine.

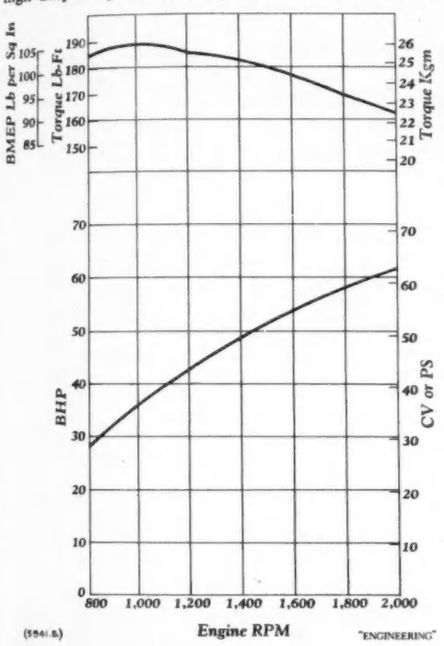


Fig. 2 Performance curves for the agricultural version.

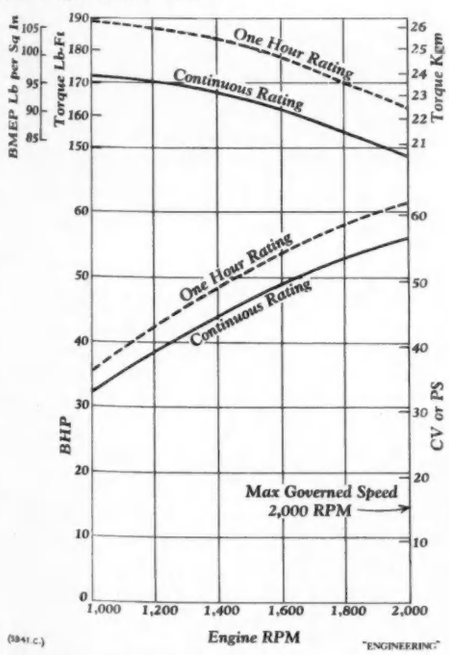


Fig. 3 Performance curves for the industrial version.

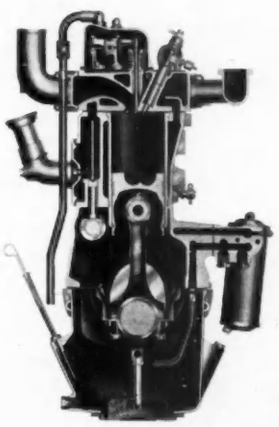


Fig. 4 Cross section of the 270 D.

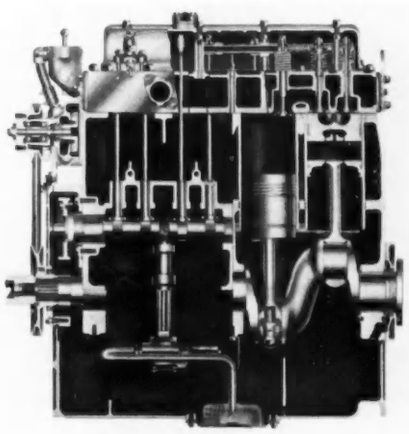
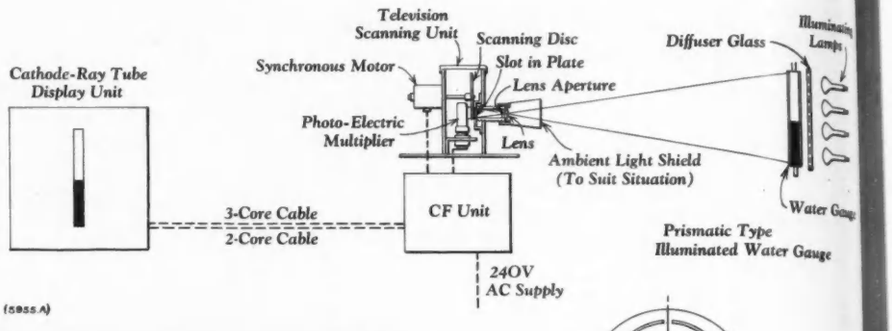


Fig. 5 Longitudinal section of the 270 D.

Continuing **Plant and Equipment**

WATER LEVEL INDICATOR

A method of solving the problem of remote indication of the water level in large boilers is the closed circuit television system that has been developed by Hopkinsons Limited, P.O. Box 27, Huddersfield. The apparatus consists of a scanning camera unit mounted to view the actual gauge glass directly, a cathode follower unit that receives the signals from the scanner and amplifies them, and a display panel placed in the view of the operator. The arrangement is shown diagrammatically in Fig. 1. For a 10 in plate gauge the scanner is mounted at a distance of 8 ft with the lens at mid level. For a 16½ in bulls-eye type the distance is increased to 13 ft 6 in. Fig. 2 shows an installation.



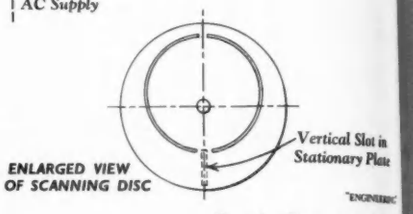


Fig. 1 Diagram of televised water level system.

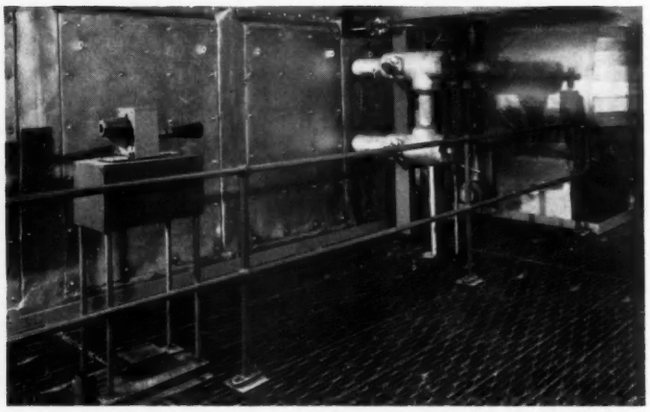


Fig. 2 A scanner and amplifier unit mounted in front of a gauge glass.

Light from behind the water gauge passes through the prismatic indicator in such a way that the steam space appears as intense clear light and the water column as dull diffused light.

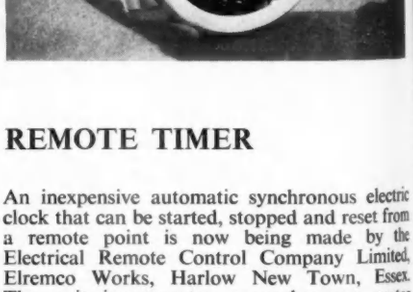
The scanning unit is placed so that the light from the gauge passes through the lens to a focal plane coincident with the scanning disc. In front of the latter is a fixed vertical slot, and as the disc rotates, the disc slot and the fixed slot together form a gate admitting light at all points along the fixed slot progressively with respect to time. Thus the gauge glass is "scanned" and the gated light is allowed to fall on the sensitive surface of a photomultiplier. The voltage produced is transmitted along a cable to the display unit, and is transformed back into light by the cathode ray tube. Deflection of the beam of light on the cathode-ray tube is exactly synchronised with the scanning motion.

The photomultiplier is insensitive to the water column in the gauge, since the main light from the illuminator, passing through water, is refracted outside the scope of the narrow vertical slot in the plate behind the lens, and the dull diffused light coming directly through the water column is insufficient to activate the light-sensitive cell of the multiplier. As a result the water column appears dark on the display panel.

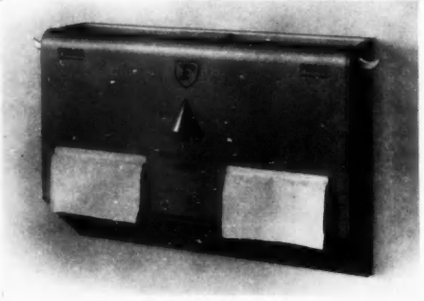
TALLY COUNTER

A tally counter the size of a wrist watch and which is also designed to strap on the wrist in the same way, is now being marketed in this country by the EJF Manufacturing Company Limited, 8 Charing Cross Road, London, W.C.2. The counter has a range up to 1999, the units and tens being indicated by the figures in the two windows, and the hundreds by the pointer on the bezel; the latter has to be turned by hand separately; the tens and units figures are moved by depressing the "winder" knob. Moulded lenses over the windows allow the figures to be viewed over a wide angle, improving readability.

When the "winder" is turned in the direction of the arrow A, (marked on the clock-face), each push advances the count by ten; turned towards B the advance is by units. This facility allows quick reseting of the counter to zero at the conclusion of a count. The movement of the Domatic counter is Swiss made and there is a choice of face colours. The fact that the outer bezel is independent of the window figures allows it to be used to denote a separate variable. A detent holds it in positon at each number.



GOGGLE CLEANER



A worker is more likely to use protective goggles if he can clean them easily. This Fleming cabinet dispenses cleaning liquid and tissues.

To make cleaning of safety goggles a simple operation, Fleming Safety Equipment, 146 Clerkenwell Road, London, E.C.1, have introduced a cleaning and de-misting cabinet which can be mounted on a wall in any convenient position. All that is necessary is to hold the goggle lens in front of the cabinet, and press either of two levers on the cabinet sides. A de-misting and cleaning spray is then directed on the lens. Clean tissues for polishing are provided at the front of the cabinet, and space is available inside it for the disposal of used tissues.

REMOTE TIMER

An inexpensive automatic synchronous electric clock that can be started, stopped and reset from a remote point is now being made by the Electrical Remote Control Company Limited, Elremco Works, Harlow New Town, Essex. The unit incorporates a synchronous motor driving a pointer through an electromagnetic clutch coupling. The motor can be running continuously and the pointer will begin to turn in a clockwise direction when the clutch is energised. Disconnection of the voltage supply from the motor of the clock stops the movement, and de-energising the clutch allows the pointer to return to zero.

The clocks are available with 14 timing dials for periods between 0 to 30 seconds and 0 to 120 hours. Front panel dimensions are 5 in by 5 in and the overall length is 6¾ in.

Companies in the News

A New Planet

A new industrial planet swept into our ken last week. The shareholders of the British Tabulating Machine Company Limited and Powers-Samas Accounting Machines Limited agreed to their two companies merging under the title International Computers and Tabulators Limited —"ICT" for short, but for long, we hope, a planet that will exert an influence throughout the industrial universe.

Thus Britain now has a company working in the data processing field which in size, experience and resources is bigger than anything outside the United States and comparable even with the dominant American organisations. The idea of the merger was first discussed by Sir Cecil Weir and Colonel A. T. Maxwell in August, 1957. They are now the chairman and deputy chairman of ICT, but at that time they were respectively chairman of the British Tabulating Machine Company and chairman of Powers-Samas. Sir Cecil said last week that the reason behind the merger is to create a great British company which can successfully compete in any market with any other company in the world in the field of mechanical, electro-mechanical and electronic machines applied to accounting, statistical, management and production control problems.

There is a wealth of experience in the two constituent companies. Sir Cecil's company, the 52-year-old BTM, were widely known as the Hollerith punched card firm, and Colonel Maxwell's company, Powers-Samas, had 43 years in the business of punched card equipment not only for large and medium-scale undertakings but also for smaller businesses not covered by the Hollerith range. Both companies had invested considerably in research into orthodox punched card equipment, being satisfied that the market for this kind of equipment will remain highly active for many years, in spite of—or perhaps because of—the interest which has grown in the application of computers. They have also been doing research on high-speed printing.

The association of BTM with the General Electric Company is to continue, and the association of Powers-Samas with Ferranti Limited is being considered. The full integration of the two companies will take place in stages, but already a close study is being made of the priorities to be given to development of markets throughout the world, in addition to the Commonwealth and European markets. ICT is represented in all countries of the British Commonwealth, the principal countries of Western Europe, and Greece, Iraq, Syria, Lebanon, Japan, Sudan, Mexico, Burma, Egypt, Kuwait and Iran. Some 16,000 people are employed by ICT and the company have very fine training and education establishments, as well as three research laboratories.

Steel Chair

The man who may have the most difficult political job in industry over the next year or two is Sir Cyril Musgrave, the newly appointed chairman to the Iron and Steel Board. Sir Archibald Forbes, the present chairman, is leaving at the end of this month.

Sir Cyril Musgrave is known to thousands of engineers and industrialists connected with the Ministry of Aircraft Production during the war and with the aircraft section of the Ministry of Supply since 1946. He was a principal in the Air Ministry when he was called upon to join Lord Beaverbook's team at MAP as an assistant secretary. Promotion came quickly and in 1946 he was under secretary (Air) in the Ministry of Supply. It is Supply he will be leaving, but from the topmost rung, as he is now permanent secretary.

The appointment of a distinguished civil servant with an unusually close knowledge of the engineering industries ensures that a fair-minded but "neutral" stand will be taken by the board in any political scuffle that may follow a change of government. Even now, the decisive and uncompromising stand of most of the steel industry's leaders against renationalisation—which has apparently brought about second thoughts on labour's part—is breeding a strained atmosphere in which the board may find it difficult to function effectively. Sir Cyril is well schooled to managing situations of this kind.

Danish Diesels

The production of Burmeister and Wain diesel engines in 1958 was a new record and accounted for over a quarter (26·47 per cent) of the total engine output of ships delivered during the year by the world's shipyards.

B and W's output during the year, including the Danish company and all their licensees, totalled 947,405 b.h.p., compared to 924,275 b.h.p. in 1957. Their nearest competitor reached 765,460 b.h.p. It would seem that the company's policy of going over to very large engines was justified and that their commercial ascendancy reflexts a technical lead built up during the post war period.

Rolling Capacity

Last year, Stewarts and Lloyds had a setback in their output like many other steel concerns. Ingot steel production fell from the record level of 1,545,000 tons in the year ended September, 1957, to 1,323,000 tons in the year to September, 1958. The chairman in his recent review said that there would be considerable capacity unfilled in 1959 at Bilston, Clydesale and Corby. Rolling mills at Bilston may be working well under capacity.

Stewarts and Lloyds have announced that their new rolling mill, which is part of the £12 million expansion programme at Bilston, is expected to be in operation in the middle of this year. The complete scheme will be installed by the end of 1960. By then the capacity at Bilston will amount to 600,000 tons of rolled steel products a year—double the present capacity. The new mill consists of a 30 in blooming mill and two 32 in reversing bar mills. There is thus going to be an additional 300,000 tons of billets and bars for the company's tube mills in about two years' time.

Like some of the other large steel groups, Stewarts and Lloyds are carrying on with their long-term expansion programme. New seamless tube capacity is being installed despite a decline in the volume of orders for tubes from the oil industry. This is the right policy for one of the world's largest producers of steel tubes. The long-term prospects for both seamless and welded tubing remains good and it is significant that even if one takes a 25 year view, by which time nuclear power may be offering a serious direct challenge to oil, Stewarts and Lloyds have already staked a claim for supplying tubes in the nuclear field.

Contrariwise

The excellent results of the David Brown Corporation during the year ended 30 June bear witness to what can be done when a general recession hits a company. Their products are, first, gears, which sell over a very wide field and are subject to the fluctuations in demand felt throughout the engineering industry; second, machine tools, which is one of the weaker areas of engineering activity; third, agricultural tractors and field implements; fourth, pipleine valves (a new venture) and fifth luxurious high-performance motor cars. By all normal expectations the company should have done not so well in the past 18 months.

Orders received during the financial year under review were £1·2 million higher than the previous year despite what the chairman called "a nervous tendency created by the recession in the United States," and over half were for export. When he wrote this statement, orders booked totalled over £7 million, enough to keep all but the foundry divisions fully occupied until next June or beyond.

The improved performance was largely attributed to increases in efficiency and to economies. Profits rose from £469,000 to £703,000, due to the neutralising effect on increasing costs in material and labour of "concerted attacts on overhead costs." Some of the economies, said Mr. Brown, have been "of a domestic nature" but are expected to be "beneficial in the years to come." Product development has not been neglected, and new products—such as the oil pipeline valve, a forage harvester, a new car, and others—are winning new markets. It is a splendid recovery, which holds out high promise.

Hawker Siddeley Divided

The integration of vast industrial activities, such as those included under the name of the Hawker Siddeley Group, is not achieved quickly and easily. Yet considerable progress has been made in a few months. In his chairman's statement, Sir Thomas Sopwith expresses confidence in the future because, he said, "we are dealing from great strength." He takes the view that research and development is "vital" to the group's future. In particular he urged that Britain should begin a programme of research "to enter the space age without delay."

The group's business is diversified to such an extent that it covers coal, iron, steel, alloys and a very wide field of heavy engineering and power plant as well as aviation. "We have tremendous resources but also the strength of great diversification. Our resources are deployed in such a way that we can move whichever way trade and commonsense dictates." Good results are expected during the current year. The group's order book is substantial and their factories, plant and equipment said to be very up to date.

The Hawker Siddeley Group have now completed the broad division of their United Kingdom manufacturing activities into two divisions, aircraft and industrial. Sir Roy Dobson is the group's managing director and in commenting on the aviation division, of which he is chairman, he said: "We have three big new projects on our plate—the Armstrong Whitworth Argosy, our private venture turbo-prop freighter coach which has been adopted for Royal Air Force Transport Command; the Avro 748 and Hawker's new vertical take-off project. In addition, of course, we have big production jobs on Vulcan V-bombers, Shackleton reconnaissance aircraft, Hawker Hunters, Javelins, Seaslug and Stand-Off-Bomb guided missiles."

Hawker Siddeley Industries is the other division, of which Sir Roy is also chairman, and will handle all the group's industrial activities. They embrace Brush Electrical Engineering, Fuller Electric, Hawker Siddeley Brush Turbines, Hawker Siddeley (Hamble), High Duty Alloys, J. and H. McLaren, Kelvin Construction Company, Mirrlees Bickerton and Day, Norstel, Petters, Templewood Hawksley and the National Gas and Oil Engine Company.

The whole Hawker Siddeley Group is therefore in a good position to take advantage of new developments in technology and manufacturing techniques. They can back very large development schemes unaided and take on the largest projects, over a field wide enough to present a good crop of opportunities during the next few years.

Special Article

ENGLISH *The Universal Technical Language?*

By EDWIN HOLMSTROM, Ph.D., M.I.C.E., F.I.L.

One of the main conclusions of this article is that the extent to which the English language is used internationally will depend very largely on the success of American, British and Commonwealth industry and engineering in maintaining their competitive position in the world as a whole. The present status of English as a technical language is examined, as well as the forces tending to spread, or diminish, its utilisation. But the future growth of Russian—and Chinese—is the chief unknown.

Dr. Holmstrom is the author of "Records and Research in Engineering and Industrial Science." After a varied engineering career and a period on technico-economic investigations for ICI, he joined Unesco's Department of Natural Sciences, where he was responsible for a bibliography of dictionaries and for the report cited in this article. He is now a translator, writer and consultant.

Is English becoming the world's technical language? Let us first examine the factors which suggest an answer "yes" to this question, then those which raise doubts.

English is the mother tongue of at least 250 million people—well over one-tenth of the world's population—in this country, in the present member countries of the overseas Commonwealth and, with differences mainly of terminology too slight to be significant for the present discussion, in the United States of America which has about twice the population of all the foregoing. Further, it is the language which educated people of whatever descent, down to the present generation, in all countries which are or ever have been members of what is now called the Commonwealth, regard as their normal medium for scientific and technical communication. It is taught as a school subject in most foreign countries, including the Soviet Union where ten million children are said to be learning English. In some countries it is the only foreign language taught.

In nearly all parts of Western Europe, Latin America and the Middle East, as well as in some parts of the Far East, there is an increasing tendency to choose it in preference to other modern languages. The British Council, which in various practical ways assists the educational authorities in countries which desire this, observes and helps to satisfy also an ever growing demand, all over the world, for teaching English to adults. Reports from such bodies as the Cambridge University Local Examinations Syndicate and others which hold examinations in English overseas, and from the United States Information Service with its many agencies abroad, all tell the same story.

HALF USE ENGLISH

Obviously this affects the intellectually occupied sections of the populations more than the generality; but it has been estimated that at the present time more than 50 per cent of the world's literate population makes use of the English language in some way or other. Here "literate" and "makes use" are vague terms, but in regard to science and technology it is possible to quote figures which, although not deserving to be called statistics, do at least suggest the relative orders of magnitude. For instance, at the beginning of a report bearing on this which has been compiled and published by Unesco[1] one thousand journals picked at random from the great *World List of Scientific Periodicals* (which covers over 50,000 titles altogether) are cross-tabulated by language and subject. The proportion in English is over one-half for engineering and manufacturing, slightly less than half for most divisions of pure science.

The same report quotes figures, which tell the same story, derived from analyses of the original languages of the articles which are referenced by the main abstracting and bibliographical services of international scope. For instance, between two-thirds and three-quarters of the 25,000 articles a year which appear in over 1,400 journals from all parts of the world and are annotated in the well-known annual volume of the Engineering Index Service, New York, are in English. The director of that service has stated in a letter that he believes this proportion represents a fairly balanced sample of what is published in all countries, at least in so far as concerns serious technical articles which would be of value to the research engineer, though there may be some bias in the direction of citing English rather than foreign language articles in the case of those which are of interest at the less advanced levels.

Chemistry enters directly or indirectly into so many branches of applied science that the language proportions of publications in this field are especially significant: here again, well over half are in English, which has overtaken German with French and Russian about on a par coming next, and then Japanese.

ENGINEERING EXPORTS

Technical publication in English is not limited to English speaking countries but occurs also in parts of Asia and in some of the smaller European countries, such as Sweden and the Netherlands, whose national languages are not much known outside their own borders. In aviation, English has become almost an international language. For engineering purposes, firms which wish to increase their export trade have a strong incentive to produce reports and publicity in English and to use our language for correspondence. Likewise in regard to research, the intellectual isolationism in which too many American and some British scientists live and do their work, as reflected in the low proportion of non-English references which they quote in their footnotes and bibliographies, may add something to the urge which foreigners feel to express themselves in or be translated into English. Several book publishing firms of international repute, operating from the European continent, are able to flourish by cultivating the American market from the outside.

To answer our question, this existing situation calls for consideration against the background of its historical antecedents. Linguists have distinguished and classified 2,796 languages, apart from dialects, spoken in the world today. Thirteen of these, in which Chinese with 600 million speakers comes first and English second, are current among more than 50 million people each. The factors which have caused a few of these major languages to spread over areas many times larger than their original homelands are complex. To some extent the purely cultural pre-eminence of a community using a particular language may help to diffuse the knowledge and use of that language, even if not, or no longer, associated with political power, or even against the currents set up by such power. Ancient Greek, which survived and which even permeated the educated classes in the Roman Empire after Rome had conquered Greece, is a case in point.

But more generally the causes of linguistic expansion have been military conquest, political absorption, religious propagation or economic colonisation in various combinations. It was due to imperialisms of these kinds that Chinese spread over its own vast territory and affected the languages of neighbouring areas; that the tongues of the peoples of Northern India and what is now Pakistan are derived from and related to Sanskrit and Persian while those of the south belong to a Dravidian group; that Latin was used for law and administration throughout most of Europe and continued as the common language of all educated men long after the Roman Empire had collapsed, continuing even today as the language of the largest and most widespread section of the Christian church; that Russian staked out its long and distant frontiers; that Arabic has covered all North Africa and much of Asia as well as imparting its beautiful but unsuitable alphabet to languages as different from itself as Turkish and Malay.

BRITISH IMPERIALISM

Later it was thus also that English became as widespread as it is, carried on the back of a British imperialism which is now a matter of history, and which took two forms: the conquest and government of countries in Asia and Africa already populated, and the settlement of migrants in what were almost empty territories on other continents, including those which now constitute the United States of America. In both cases, culture was transplanted from Europe to flourish in new soils and the language of that culture was English. Pure science is a branch of culture and the graftings added to it by British leaders from Bacon and Newton and Darwin down to

the present day, using the English language, have been second to none in vigour. On the side of engineering and industry the picture is similar: here the lead which Britain achieved during the 19th century—and still maintains in many fields including new ones like nuclear energy—has combined with the immense technico-economic activity of the North American continent in our own time to create, as we have seen, a powerful urge in other language areas to learn English as a means of sharing in the general ferment which American and British technical literature helps to propagate.

It is evident, then, that technical use of English has acquired a very considerable momentum apart from the countries in which it is native. What we have to consider here is whether this momentum is likely to be braked by the fact that erstwhile British imperialism is now, politically speaking, running in reverse and making colonies independent as quickly as is considered safe to do or, on the other hand, is likely to be further increased by reason of continued growth in the importance of American, British and Commonwealth industry, and engineering relatively to the rest of the world.

The braking effect on the spread of English which is to be expected when a country hitherto under British rule becomes independent is touched upon in the Unesco report aforementioned. In such circumstances, as is there remarked, " the use of national languages for all purposes including science is felt as part of the very stuff of exuberant nationhood, an essential element in the ability to say 'we'. Inconvenient as this may be from the point of view of internationalising science and ridiculous as it may become when carried to excess, it cannot be altogether condemned as insubstantial sentiment. It is natural for the peoples concerned to expect that an efflorescence of their national cultures will best be fertilised by using their own languages. . . . Educationally, some consider it unsound to make a foreign language the means of developing the capacity for thought."

On the other hand, a country which insists on using a language (or worse, a multiplicity of languages) unknown outside its own borders in preference to one of the main scientific and technical languages condemns itself, as far as it chooses to go, to the status of a scientific and technical hermit. This dilemma must be regarded as a consequence of the curse of Babel from which there is no escape.

TREND IN INDIA

Here the trend in India is instructive, as summarised in the Unesco report and in a short special article by the Delhi correspondent of *The Times*.[2] In the whole sub-continent over one hundred languages and dialects are spoken, mostly belonging to the two groups mentioned above. In the undivided Indian Empire under British rule the language of secondary and higher education and of pure and applied science was English, which however is written and read up to school leaving standards by only some four million people, and for which there is now a shortage of teachers.

Under the Independence Act of 1947 the sub-continent was split into two separate sovereign units, the Indian Union and States with nearly 357 million people, and Pakistan with 76 million. The Indian Constitution of 1950 laid down that " Hindi in the Devanagari script," described as the Federal language, should within 15 years replace English as the official language of the Union, while at the same time 14 Regional languages were to be recognised for internal communication among the millions or tens of millions of people whose mother tongues they are, and to be used in primary education. The basis of this decision is that Hindi (which derives its vocabulary directly from Sanskrit) is closely similar to Urdu (now the official language of Pakistan, which is written from right to left in Persian script and has many words from that old court language of the Mogul conquerors) and to Punjabi which lies in between, these three making a total of some 150 million speakers, in addition to whom there are about 87 million using four or five other languages of Aryan origin who are in somewhat the same favourable position for learning Hindi that a Swede is for learning German or a Spaniard for learning French.

Representatives of the Dravidian languages in the south, to whom Hindi is practically as much a foreign language as English, object, however, that the attribution of any " national " standing to Hindi is an attempt by a minority to impose its will on a majority, and controversy has never ceased. Recently the Congress Party, which supports Hindi, impressed with this opposition, unanimously adopted a motion emphasising the need for a gradual transition and allowing for the possibility of English being continued in use after 1965. The other side, still not satisfied, have countered with a new proposal that both Hindi and English should be permanently established as alternative national languages.

Meanwhile the University Education Commission of 1948-49 made recommendations (quoted in the Unesco report) as to the use of the federal and regional languages, and the continued teaching of English, at appropriate levels in secondary and higher education; also " that international technical and scientific terminology be adopted, the borrowed words be properly assimilated, their pronunciation be adapted to the phonetic system of the Indian language and their spelling fixed in accordance with the sound symbols of Indian scripts."

The general problem of creating suitable terminologies in languages hitherto not used for modern scientific purposes is one of those receiving attention by Unesco. In India, satisfaction of this need is proving a formidable task and has not yet gone very far. It is reported that in 1957, when the Soviet Government supplied the nationalised Indian air lines with technical data on the Ulyushin 14 aircraft in Hindi, the terminology proved so incomprehensible to the Indian experts for whom it was intended that the brochures had to be translated into English for them !

India perhaps is an extreme case, but in general it may seem a fair conjecture that the ultimate result, linguistically, of countries formerly under British tutelage becoming independent—whether they remain in the Commonwealth or not—will be a great reduction though not total elimination of English for most internal purposes, some continued use of English at the higher levels of science and technology even internally, and acceptance of English as the normal medium of communication, on these matters, with the outside world.

THE PEI PLAN

Further, if the plan lately put forward by Professor Mario Pei of Columbia University, New York, were to be agreed upon and carried out, it would evidently be in the interest of those countries to vote for the English language as an international connecting link. This plan is an attractive one. Its author, a distinguished linguist, develops a thesis which he says is accepted by four-fifths of those questioned in Gallup polls among the general public in several European countries as well as in the United States where there is relatively little awareness that language problems exist. His thesis is that " one of the greatest needs in the world today is *a* language spoken and understood by everybody "—here italicising the indefinite article because he contends it does not really matter very much which particular language, whether a naturally existing language or an artificial one like Esperanto, is chosen for the purpose as long as every country will adopt *the same* language and will cause this to be taught and used in all its schools as nearly as possible on a par with the mother tongue, starting at the earliest possible age (in the kindergarten or its equivalent) when conversational bilingualism, later convertible to written, comes without effort. (That this is so is proved by countless examples, the present writer and two of his daughters among them.)

What has stalled all international language movements in the past, argues Professor Pei, is that their supporters have invariably put the cart before the horse by arguing the merits and refuting criticisms of their particular pet language instead of securing general assent to the proposition that some one language must be internationally adopted. He sees no hope of any " movement " led only by a group of private enthusiasts being able to persuade the world that what it advocates is right and all others wrong. What he proposes, therefore, is the following sequence of steps: (1) Induce *governments* to accept beforehand the obligation, after some one language shall have been agreed upon, to arrange for that language to be taught in all schools. (2) Hold a conference using a procedure designed to prevent any further time being wasted after the proponents and opponents of each suggested language have been given a set time to state their case, before proceeding to the vote by a succession of eliminatory ballots. (3) Leave an interval of five years to allow time on the one hand for any necessary trimming of the chosen language to make it suitable for international use (such as by phoneticising its spelling) and on the other hand for teacher training. (5) Put the scheme into top gear, so that 20 years later everybody, in all the participating countries, will be able to inter-communicate. In countries like Ceylon where there are several local languages, or like India where there are many, the chosen international language could also be useful internally.

Disregarding the possibility of English being chosen, on its merits, for general international use if the Pei plan were adopted, it may well happen that *if American, British and Commonwealth industry and engineering maintain their competitive position* in the world as a whole, the value of being able to read their technical literature will more than compensate for local recessions in the demand for a knowledge of English in countries which have recently become independent of British rule. But this last " if " is a crucial one, for the following reasons. The language in next widest technical use after English is now Russian, or soon will be, and Russian is the leading (though not the only) language of a population now exceeding 200 million, which includes a proportion of technologists and scientists at least as high as in the United Kingdom, approaching or perhaps exceeding that in the United States; a language associated not with an imperialism in reverse in the sense that expression has been used here but with a militant political expansionism.

Finally, let us not forget that every fourth or fifth person in the world is Chinese, belonging to a nation markedly intelligent and very hard working, three times as populous even as the Soviet Union and now committed by its government to full scale industrialisation.

REFERENCES

[1] *Scientific and Technical Translating and Other Aspects of the Language Problem.* 2nd edition. Paris: Unesco. (London: HMSO, P.O. Box 569, S.E.1). 1958. (20*s*).

[2] " India's Language Problem, p. 11, *The Times*, 17 March, 1958.

[3] Pei, Mario. *One Language for the World.* New York: Devin-Adair Company. 1958.

The Human Element

What an Engineer Should Be

The production of graduate engineers in the United States is being stepped up considerably and a great deal is being said about the kind of education a professional engineer should have. At the University in Illinois in Chicago, the Associate Dean of Engineering, Mr. Fred W. Trezise, has been to the forefront of the " new look " advocates of the education which fosters the development of the whole personality of the student. In a statement presented during a panel discussion before President Eisenhower's Committee on Scientists and Engineers he described a profession as " not a class, not a calling, but an attitude of mind."

The kind of education which fosters this attitude of mind is defined in the report of the American Society for Engineering Education on *Evaluation of Engineering Education* (generally known as the Grinter Report). " The broad social goal of engineering education includes a development of leadership, the inculcation of the deep sense of professional ethics and general education of the individual. The development of both a personal philosophy which will insure satisfaction for the pursuit of a productive life and the moral and ethical values consistent with the calling of a professional engineer."

The Western Society of Engineering in Chicago asked the presidents of fifty-two concerns for their viewpoints " on the deficiencies which they note in the engineers in their employ." The thirty companies who replied agreed almost unanimously that the technical training of their engineering employees was competent. What was missing is best revealed from the following extracts from their replies—" Competent and inspiring teaching is of paramount importance in the study of humanities and social science." —" Lack of ability to co-operate and get along with other people."—" Personality, cultural development are combinations we have been searching for."—" Cultural and humanistic development of the engineer both in college and afterward is of major importance."—" Technical education of engineers, needs to be considerably bolstered with general educational course, liberal arts—he should be a 'whole man '." The University of Illinois is currently developing a new campus " looking forward to some 20,000 students in ten years. With such conceptions of broad education and philosophical approach, the results should be worthwhile."

Developmentships

Mr. Richard Steel, managing director of Servomex Controls, of Crowborough in Sussex, does not believe in apprenticeships. Though once a way of learning a craft, essentially creative and rewarding, it had become in many cases merely a prologue to minding a machine. " Servomex," he said, " do not take on apprentices. They take on men and women who are invited to make the most of themselves within the fast-growing organisation. This means literally that, providing the individual can demonstrate that he is equipped to do a particular job in Servomex, no labels, trade, social or educational, stand in his way." The only permanent label that a man would carry was his name; and his course of training and advancement might more properly be termed a " developmentship."

There have been many previous attempts to escape from the restrictive attitudes fostered by traditional apprenticeships. Trade unions, by their very name, are a reflection of the old system and exhibit all its limitations and drawbacks. But they are there to safeguard the interests of members and the fact that many members—probably a majority—still fall into " trade " classifications is convenient for the purposes of organised labour. Taking a long view many union men would agree with Mr. Steel, but what of the transition period? Demarcations and apprenticeships are means of " protecting " a trade from too great an influx of recruits or too much " poaching " from other trades.

But although there is inevitably resistance to departures from traditional practice, nothing succeeds like success. Many of the people who have benefited from the company's liberal attitude towards training and education have in six years " more than doubled their earning capacity." Facts of this kind are the best of testimony.

Educating Our Masters ?

The Engineering and Allied Employers' National Federation have issued a booklet called *Looking at Industrial Relations*. It is mainly descriptive, dealing in 10 sections of 48 pages with the federation's work. It is also a defence of federation policy, mainly of the recent past.

Booklets of this kind, even when well-produced, as this one is, are difficult to assess. Who are they aimed at? The trade unions? Surely not: what engineering operative is going to read through 48 pages of description of the " bosses " federation. At non-federated engineering employers? Then there is nothing very striking to make them feel they should join. At their own members? They must know, or have access to, the sources of information already. Then it must be addressed to " them "—an amorphous group coming from all these national interests and from the public as well. It would have helped if there had been a brief foreward to attract the attention of the reader for whom the booklet is intended or a more specific less equivocal title. The brochure is not, for example, about industrial relations in general.

Granted these limitations, however, there is a good deal of useful information about the employers' federation within its pages. Anyone wishing to follow through the recent history of engineering wages negotiations from the employers' point of view will find it here.

Awards for Initiative

At a time when so much public and private money is being spent on training schemes and scholarships in industry it is right that there should be a few which are out of the ordinary. In line with this is the announcement by the Society of British Aircraft Constructors Limited that the trust fund set up by Sir Geoffrey and Lady de Havilland in memory of their son John, killed on a test flight in 1943, is to have its purpose changed. Originally, it was set up to help boys who were in straitened circumstances wishing to become apprenticed to the aircraft industry. No applicants have come forward in recent years.

The SBAC (as administrators) now announce that the award will still be associated with the aircraft industry but it is to be used to develop the power of leadership. The emphasis is to lie in " the spirit of adventure, initiative and resource." The award is for £400 and one will be made in each year. Candidates are invited to make their own proposals and should be between 18 and 25 years of age. They will be judged on their record, merit and character and on the originality, resource and value of the scheme.

Such schemes, if limited in number, are valuable but they have drawbacks. They are apt to be as large a test of resourcefulness for the adjudicators as for the candidates. They involve the former in a series of exceedingly difficult subjective evaluations. How does one judge capacity for leadership in young men from a scheme to spend money and other people's written (and often routine) evaluations? Few prizemen at Sandhurst become Field Marshals. Leadership and resourcefulness are forged out of experience adversity and the like. Able and likeable young men may have it but it is just as likely to lie dormant among those less superficially impressive at that age.

Apprentices are Going Places

From time to time a development is announced on the more prosaic side of industrial activity which comes as a reminder that times are changing. Such a one has been the recent announcement by the Plessey Company that it is planning to give its prize apprentices three to six months' tours in America. The tours will include visits to some of the American companies which are associated with Plessey.

This is a most imaginative idea. It also prompts the thought that the cost per apprentice of running apprenticeship schemes must be rising very steeply these days for one reason and another. In consequence there is likely to be a tendency for companies to try to keep their apprentices and get something back on their investment. In so far as this means a rapid promotion of the able through different journeymen grades, it is all to the good. If it should mean an increasing number of strings to apprenticeship agreements to limit the mobility of labour there will be less cause for approval.

The Plessey Company are also considering the possiblity of starting commercial apprenticeship schemes which will be open to girls as well as boys. This last possibility throws an interesting light on the state of the labour market and larger number of openings which are becoming available to women. Extending such schemes to women, however, raises a large number of problems, for the wastage rate of women in industry is inevitably high and it is doubtful if apprenticeship will do much to lessen it.

African Craftsman

The shortage of technically trained people and the problems involved in ensuring an adequate supply of skilled manpower in West and East Africa are discussed in the January issue of the United Africa Company's *Statistical and Economic Review*. The authors discuss Africa's needs in the light of considerable local knowledge of countries where Unilever have been active for many years, such as Ghana, Nigeria, Sierra Leone and Gambia in the West, and Kenya, Uganda and Tanganyika in the East. " Without skilled and experienced manpower," they write, " capital cannot be fruitful nor development plans implemented." Hence the incentives to do something about it, heightened as they are by national aspirations, are considerable. So are the handicaps. Tropical Africa has no mechanical tradition. There is a lack of familiarity with tools and technical terms, and a cultural background less suited than that of Western society to produce industrial workers.

The authors draw mainly on the experience of the United Africa Company and quote extensively from their many schemes. They date back to the appointment of a technical training adviser—with long experience of similar work in India—in 1952. Two years later the first school was opened at Burutu in Nigeria and, being successful, was followed by a further five schools in West Africa and one in East Africa. These schools provide five types of training: a five-year course for " indentured " apprentices; a two-year course for trade trainees; " booster " classes for craftsmen and supervisors; courses in new techniques and evening classes. Some 400 of the company's employees are currently undergoing training at these schools.

The United Africa Company's decision to spend large sums of money to train increasing numbers of Africans into craftsmen and technicians was enforced by the acute shortage of technical, specialised and managerial staff. They are now making a major contribution to the local resources devoted to education. This little book is a most interesting commentary on Africa's problems and on her potential.

Automobile Engineering

MG MAGNETTE

The new MG Magnette is the latest of the BMC line to be rejuvenated with a body designed by Pinin Farina. The four-door unit construction saloon is similar to those used on the new Wolseley 15/60 and Austin A.55 but has shorter tail fins and a different front with a new version of the traditional MG radiator. Engine, transmission and suspension are little changed except that the rear axle ratio is higher. Maximum speed is said to be about 85 m.p.h. and fuel consumption 38·8 miles per Imp. gallon at a steady 40 m.p.h. or 29·4 m.p.g. at a steady 60. Wheels are smaller and brake drum diameter is accordingly reduced from 10 to 9 in, but overall braking power is greater; front brake drums are 2¼ in wide and total brake lining area is increased to 147 sq. in, a gain of nearly 10 per cent. Brakes are now Girling instead of Lockheed. Interior finish is in MG style with instruments grouped in a matt cowl in front of the driver, leather upholstery and short remote control gear lever on the floor.

The 1,489 cc BMC series B engine has new inlet and exhaust manifolds and two new 1½ in SU diaphragm type carburetters said to permit easier adjustment and give smoother idling than the old type. Maximum power is unchanged at 68 b.h.p. (SAE) at 5,400 r.p.m., but torque is up slightly to 85 lb ft at 3,300 r.p.m. Tank capacity is also increased to 10 Imp. gal.

The clutch is hydraulically operated. Gearbox ratios are unchanged but axle ratio is now 4·3 to 1 instead of 4·55 to 1. Allowing for the use of 5·90-14 tyres against the previous 5·50-15 this gives a slight increase in road speed for a given engine speed (16·54 m.p.h. at 1,000 r.p.m. in top). Weight is slightly higher than before. Steering is by cam and peg in place of the former rack and pinion, to reduce road shock. Front suspension is by wishbones and coil springs without anti-roll bar. Rear suspension is half

elliptic; all dampers are piston type. Wheelbase is reduced by about 2½ in compared with the old car, and front track is about 2 in less but the length is increased by 9 in, and height is slightly greater. Ground clearance, head room, leg room and elbow room are maintained or increased.

Leather upholstery, pile carpets and walnut veneer for door cappings and facia panel set the tone of the interior. The matt black of the leather crash pad on top of the facia matches that of the instrument panel and its cowl, and the horn ring on the 17 in drop-centre steering wheel is cut away at the top to allow a clear view of the instruments. These comprise speedometer with trip and total readings, fuel gauge, oil pressure gauge, engine thermometer, and ammeter. There is no tachometer, but an electric clock is fitted centrally between the air and water controls for the heater and demister unit. Control switches are the snap-action toggle type so the light switch can be used to flash the headlamps. A trigger below the steering wheel works self-cancelling direction indicators. It has a warning lamp on its end which is automatically dimmed at night.

Door locks are the new zero-torque non-slam type with safety catches on the door edges where children cannot reach them. All four doors have winding windows and swivelling ventilation panels. The book is big and unobstructed with a flat floor; capacity 19 cu. ft. The spare wheel is housed in a separate-wind-down cradle below.

In Parliament

BRITISH TENDER REJECTED

Comment was made by several peers in the House of Lords last week regarding the American rejection of English Electric's bid to provide two turbines for the Greer's Ferry hydro-electric project.

Lord Stonham (Labour) asked the Government to state their plans for the protection of British firms who, having accepted invitations to tender for installations and equipment in the United States, find, after submitting the lowest tender, that they are denied the contracts on grounds of alleged "national security." He pointed out that the vigorous protests that had been made, which his party strongly supported, had apparently been rejected by Mr. Dulles, who, in answer to protests at this "un-American activity," had said that the decision was an honest one. How could Britain free restrictions on dollar imports if the Americans were to be able to stop British exports to their country "on any pretext"?

It should be suggested to the United States Government that they could make up their minds whether the supply of two turbines was a matter of national security before inviting British firms to tender, and not after those firms had been successful. A great expense was involved in tendering and the Government should demand compensation for the losses which British firms sustained.

Lord Shepherd (Independent) suggested that the present instance was not an isolated case and felt that similar pressure had been brought to bear to prevent the adoption of the Decca electronic system for the navigation of international aircraft and shipping, which was well-known to be cheaper and more efficient than the American system. Lord Henderson (Labour), Viscount Elibank (Liberal) and Lord Conesford (Conservative) also criticised the American attitude.

LIBERAL TRADING

The Earl of Dundee (Minister without Portfolio) replying, said that, under the Buy American Act, the United States Government was entitled to reject any order on grounds of national security, which they did in this case. The matter was referred to the Office of Civilian and Defence Mobilisation, which stated that if the present procurement were not awarded to the domestic producer, there was reason to believe that the domestic productive capacity in the United States would be reduced to a level inadequate for emergency requirements. The United States Government must be the judge of their own security. There was nothing that could be done about compensation.

All that could be done was to say that this sale would have represented an extremely insignificant proportion of their total need of the kind of material in question, that the security issue was not raised until the last moment, and that, of course, this sort of action did not increase confidence in the sincerity of the American Government in carrying out the liberal trading policies, into which both they and the British Government had entered.

As to whether the present was an isolated case, he would not like to say without notice.

FROST DAMAGE TO MOTORWAYS

In the Commons, Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, referred to the damage caused by frost on motorways. He said that the construction of the Preston by-pass had been carried out by the Lancashire County Council, acting as his Ministry's agents, to a design which had been approved by the Ministry's engineers. On 20 January, frost damage was found to have affected about 1 per cent of the carriageway surface.

Closure would not normally have taken place, but, having regard to the height of the embankments and the high speeds permissible on that motorway, the road was temporarily closed on the advice of the Lancashire County Police. The immediate cause of the trouble was an excess moisture content under portions of the road's surface. The type of construction employed had been used with complete success on many occasions on other roads. The rate of construction and the completion dates for the road were matters for the agent authority but he wished to make it quite plain that he fully supported the Council in the course they had pursued.

NO PUBLIC INQUIRY

Answering points raised by Mr. G. R. Strauss (Labour), the Minister said that whether similar difficulties were likely to be encountered in building the London-Birmingham motorway did not arise, because that road was being constructed to quite a different specification. If work was to be pushed forward—as was the country's wish—on a motorway, or any other road, some problems were bound to arise. As to whether cheap forms of construction had been used, the Ministry had been deeply concerned in discussing fully with the Lancashire County Council, as far back as 1954, the method of construction, because the Preston By-pass needed embankments 60 ft high in places, and there must be some contingent risk of settlement. Accordingly, a flexible form of construction was agreed, by all the parties concerned, to be the right one.

Both the autobahnen, in Germany, and the Alaska Highway, to give but two examples, had been extensively damaged by frost. A report was being published at once giving the results of an investigation into the causes of the damage and outlining methods of dealing with the situation. It would be seen that the report was a factual record of the position, that no blame imputed to anybody and that no public inquiry was needed.

Construction of Tamar Bridge

Requests were made by Miss Joan Vickers (National Liberal and Conservative) and by Mr. F. H. Hayman (Labour) that the Plymouth City Council and the Cornwall County Council should be granted permission to borrow money to enable the Tamar Bridge Joint Committee to start work on the bridge this spring. Mr. J. E. S. Simon, the Financial Secretary to the Treasury, said that the Chancellor of the Exchequer was considering with the Minister of Transport proposals by the joint committee for a starting date. Until that was settled, the question of borrowing did not arise.

London-to-Southend Line Electrification

Mr. G. R. H. Nugent Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, told Mr. John Parker (Labour) that the British Transport Commission had informed him that the Fenchurch Street-to-Southend railway electrification scheme was proceeding according to plan and was likely to be completed in 1961. Recent progress included the extension of station platforms and the improvement of their lighting. The installation of the overhead structures was also well advanced and the overhead wiring had been begun. The new marshalling yard at Ripple Lane had already been partially brought into use. Further, the main flyover at Barking had been completed.

Shipbuilding Orders Decline

According to an answer by Mr. T. G. D. Galbraith, the Civil Lord of the Admiralty, there has been a steady falling-off of shipbuilding orders during recent years. He informed Mr. S. S. Awbery (Labour) that, while orders to British shipyards totalled 2,428,000 gross tons in 1955; 2,283,000 gross tons in 1956; and 1,823,000 gross tons in 1957; orders placed in 1958 amounted to only 515,000 gross tons. Orders cancelled, he told Mr. Frederick Willey (Labour), had increased from 121,000 gross tons, in 1957, to 396 000 gross tons in 1958.

Thirteenth in a Series of Consolidated Reports

CHEMICAL PROCESSING

By

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Experimental Reactor Establishment

It was not to be expected that the papers presented to the Second International Conference on the Peaceful Uses of Atomic Energy in the fields of chemistry and chemical processing would reveal any startling new developments or processes, or that it would have the impact of the First Conference on technical and lay opinion.

The two hundred papers which fell within the subject of this report were in very many cases review papers, consolidating information which had become available to specialist workers during the last two or three years through journals and conferences. One notable exception to this was the idea of the " Zebra " column which was also shown in the United States scientific exhibition as a small working model. In this column the plates are alternately polished steel (wetted) and epoxy-resin coated steel (non-wetted), so that the organic solvent as it passes up the column changes after one plate from dispersed to continuous phase, and back again after the next.

Another substantial advance was the discovery of the very considerable increase in decontamination factors which can be achieved by a dual temperature TBP solvent extraction process for uranium and plutonium separation.

Much progress has been made in direct methods for extracting uranium values from ores, and in continuous or semi-continuous processes for the production of uranium oxides and fluorides.

In this summary report the countries from which papers have been sent have been especially noted since it is of importance to see how widespread is the interest in chemical processing despite the substantial lead obtained by the UK, USA, and USSR. The main emphasis has been given to separation processes which have reached industrial exploitation on an engineering scale, and less to the basic chemical aspects.

Uranium Ore Processing

Ore to Oxide.—The winning of uranium values from ore is a subject engaging the efforts of chemists in many countries, whether concerned as suppliers or as users. The tendency in recent years has been for the producing countries to refine as far as a fairly pure concentrated oxide which is then exported to the user country for conversion to metal. Thus South Africa in a group of papers (P1116[1], 1117[2]) describes plant and processes for extracting and concentrating by ion exchange the uranium from the gold-mining residues. An Australian paper (P1096[3]) describes a " jigged-bed " ion exchange process. This is a new approach characterised by the use of a pulsating flow to create a semi-fluidised bed of absorbent which can be mechanically handled. The process will work with fine slurries.

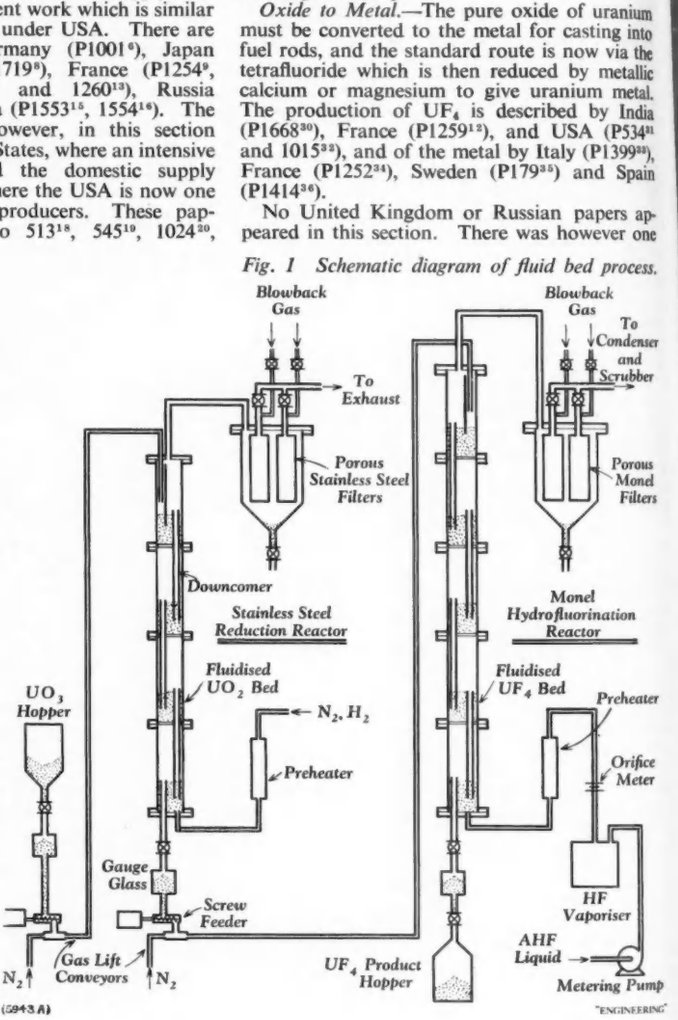
Canadian papers (P227[4], 228[5]) describe not only present day processes used in producing a very high proportion of the world supply, but also the latest development work which is similar to that discussed below under USA. There are also papers from Germany (P1001[6]), Japan (P1361[7]), Hungary (P1719[8]), France (P1254[9], 1255[10], 1256[11], 1259[12] and 1260[13]), Russia (P2064[14]) and Argentina (P1553[15], 1554[16]). The largest contribution, however, in this section comes from the United States, where an intensive effort has transformed the domestic supply position to the point where the USA is now one of the world's major producers. These papers (P496[17] through to 513[18], 545[19], 1024[20], 1066[21]) show that real advances have been made in more direct methods with fewer stages and less handling; thus ores can be leached, generally as slurries or suspensions, in contact with organic solvents and then washed back into water as a substantially pure product (P496[17]). New selective agents such as tertiary amines (P510[22]) have found increasing use especially when other metals normally interfering are high. Certain acidic and neutral organo-phosphorus compounds have also been used industrially. Alternative processes go directly from crude ore to pure UF_4 (P506[23]) and one scheme takes uranium from the ore to UF_6 (P1552[24], 525[25]) by fluidised bed and distillation processes.

Several papers on the more chemical aspects of leaching, purification, or reduction processes were submitted, for example, four from Israel (P1605[26] through 1608[27]) which deal with the chemical treatment of phosphatic ores, and six from Spain (P1413[28] through 1418[29]) of which the first gives a good account of pilot plant experience using TBP extraction followed by ion exchange clean-up.

Oxide to Metal.—The pure oxide of uranium must be converted to the metal for casting into fuel rods, and the standard route is now via the tetrafluoride which is then reduced by metallic calcium or magnesium to give uranium metal. The production of UF_4 is described by India (P1668[30]), France (P1259[12]), and USA (P534[31] and 1015[32]), and of the metal by Italy (P1399[33]), France (P1252[34]), Sweden (P179[35]) and Spain (P1414[36]).

No United Kingdom or Russian papers appeared in this section. There was however one

Fig. 1 Schematic diagram of fluid bed process.



GENEVA DISTILLATE

Prolific in papers and enormous in scope, the Second International Conference on the Peaceful Uses of Atomic Energy can only assume its true significance when the information presented there has been thoroughly digested. As a stage in this process, ENGINEERING has commissioned sixteen specialists to summarise the matter of the Conference under a number of subject headings. The process may be regarded as one of distillation, with concentrated fractions drawn off at various levels. The contributors have consolidated the information published during the Conference, selecting the essentials, reconciling the submissions of different authors and countries, and tabulating the most important data. As an introduction to the series, we published on 19 September Sir John Cockcroft's overall survey of the Conference. The present series is being published at weekly intervals and will include sixteen articles in accordance with the table. The Conference was held in Geneva from 1 to 13 September.

Power Reactors (28 Nov., page 694) ..	Mr. G. W. K. Ford, Research Manager, Dounreay
Research Reactors (21 Nov., page 662)	Dr. V. S. Crocker, Reactor Division, Harwell
Thermonuclear Research: (Pinch Effect) (19 Dec., page 796)	Dr. A. A. Ware, AEI Research Laboratory
(Other Devices) (26 Dec., page 824)	Dr. R. J. Bickerton, Controlled Thermonuclear Research Division, Harwell
Propulsion .. (7 Nov., page 600)	Mr. B. T. Price, Reactor Division, Harwell
Radiation Shielding (31 Oct., page 568)	Mr. J. D. Jones, Reactor Division, Harwell
Reactor Engineering (5 Dec., page 730)	Mr. R. P. Kinsey, Chief Engineer, Advanced Reactor Design Office, Risley
Metallurgy and Fuels (23 Jan., page 106 and 30 Jan., page 136)	Mr. L. M. Wyatt, Technical Manager, Risley
Instrumentation (12 Dec., page 762)	Mr. R. B. Stephens, Mullard Equipment Ltd.
Nuclear Physics (24 Oct. page 536)	Dr. M. J. Poole, Nuclear Physics Division, Harwell Dr. M. Sowerby, Nuclear Physics Division, Harwell
Radioactive Isotopes (14 Nov., page 634)	Mr. E. R. Wiblin, Isotope Division, Harwell
Isotope Separation	Mr. F. I. Hurley, Head of Laboratories, Capenhurst
Chemical Processing	Dr. R. Hurst, Director, Dounreay
Radiation Protection	Dr.I. S. Eve, Radiobiological Adviser, Health and Safety Branch
Reactor Safety	Mr. F. R. Farmer, Head of Reactor Safety Division, H & S Branch

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British (P300[37]) and one US paper (P523[38]) concerned with the reduction of UF_6 to UF_4, a process which is required to convert the enriched (or depleted) gaseous product of the diffusion plants to a useable form. The preparation of UF_6 is described in P1840[39] (USA).

The most interesting papers in this section were undoubtedly those dealing with moving bed and fluidised bed processes for drying or calcining oxide, and for hydrofluorination to UF_4 (see Fig. 1). Such continuous processes are clearly destined to supersede the older batch processes, and models of suitable equipments were shown in the scientific exhibition by the United Kingdom, United States and Canada, and described in papers P229[40] (Canada), P542[41] and P1922[42] (USA).

Although the time has not yet arrived for the exploitation of thorium as a source material for nuclear energy, some effort is naturally already being put into the refining of the ores and the extraction of the metal. Thus the United Kingdom sponsored a paper on the treatment of monazite sands, rock monazite and thorite (P1526[43]). The French processes for treating urano-thorianite were discussed in P1257.[44] These authors and also those from India (P1670[45]) and Russia (P2154[46]) favour the use of TBP extraction, with precipitation of oxalate for cleaning-up, whereas a paper from the United Arab Republic favoured precipitation of double sulphates and hydroxide.

Several papers were presented in the preparation of pure compounds or of the metal. The chlorination route was described in one British paper (P1468[47]) and the preparation of very pure thorium on the small scale by reaction of iodine-thorium carbide (van Arkel process) was reported in an Australian paper (P1098[48]).

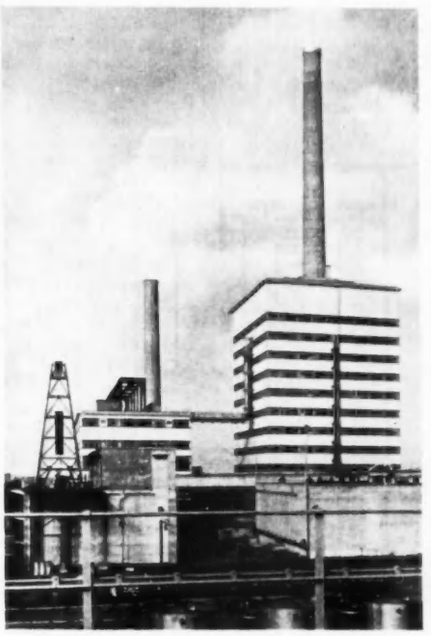
Processing Irradiated Uranium

Natural Uranium and Thorium.—All those countries which already have a nuclear power programme presented chemical flowsheets for the chemical separation processes necessary to treat natural or slightly enriched uranium fuels after irradiation. All these large-scale production plants use variations of the solvent extraction process in which uranium and plutonium are extracted into an organic solvent, leaving the major proportion of the fission products in the aqueous raffinate. In the United States two processes appear to be still in use: the "Redox" system using hexone as the organic solvent and the "Purex" system using a solution of tributyl phosphate (TBP) in kerosine. The British "Butex" process (P307[49]) uses $\beta\beta'$ dibutoxy diethyl ether for the initial separation of the uranium plus plutonium from the fission products in gravity-fed packed columns, but changes to a TBP process in pulsed columns for the final clean-up of the plutonium stream (see Figs. 2 and 3). The British process makes use of an oxygen purge through the nitric acid of the dissolver into which the uranium rods are fed continuously. This absorbs the nitrogen oxide gases, reconverting them to nitric acid, hence the term "fumeless dissolving." Plant decontamination and maintenance is discussed and valuable operating experience, particularly on control, is given.

The French plant at Marcoule uses the same principle in the dissolver and then uses mixer-settler units for contacting the aqueous and organic phases (TBP in kerosine was the chosen organic extractant). Some ingenious analytical and automatic control instruments for this plant were described (P1174[50]).

The Russian process for treating the irradiated elements from the first atomic power station in the Soviet Union was required to deal with stainless-steel cladding and fuel elements containing 9 per cent by weight of molybdenum, and 12 per cent of magnesium (P2182[51]). The rods were cut into short lengths and then fed to a dissolver for dissolution in nitric acid.

Fig. 2 Primary separation building at Windscale.



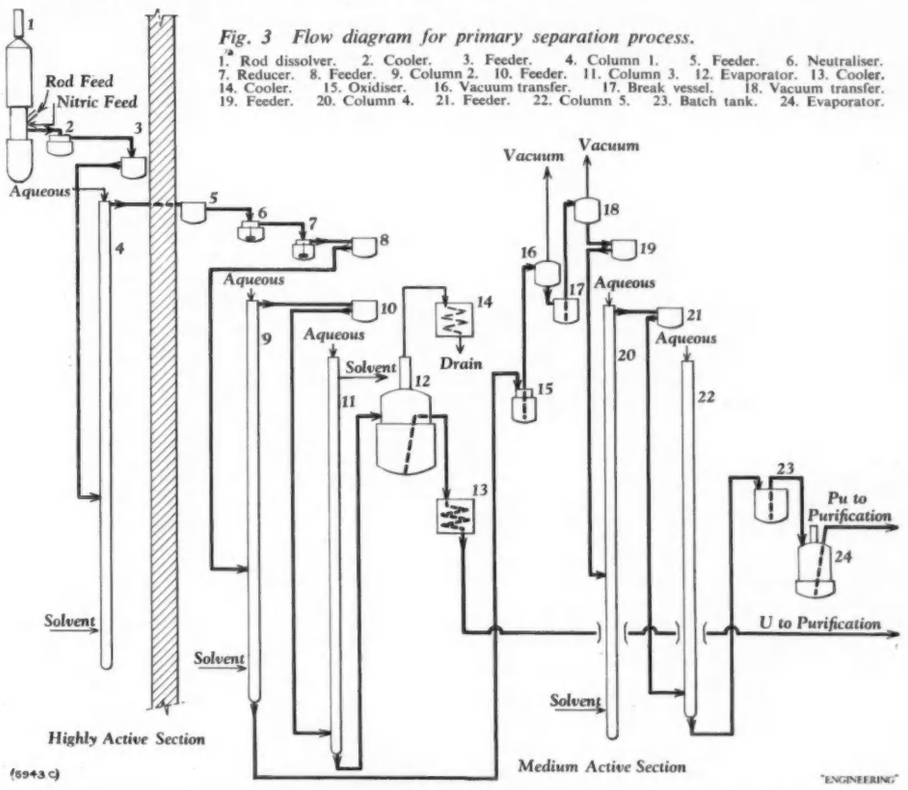
To obtain stable solutions containing such a high concentration of molybdenum, ferric nitrate was added as a complexing agent; from this solution TBP in kerosine will extract uranium and plutonium very readily, and molybdenum only very slightly. Phosphoric acid could also be used as a complexing agent for the molybdenum, but in this case the uranium only is extracted into TBP-kerosine initially from the 5M HNO_3 solution. After treatment with salting-out agent (aluminium or iron) the plutonium can then be extracted. Good extraction and decontamination factors were claimed for this process.

Certain other countries have arrived at the stage of pilot-plant work, undertaken either to get experience, or in the hope of finding an improved process or one tailored to their specific needs. Thus Norway (P585[52]) is building a 3 tonnes per year plant at Jener based on extraction into TBP in gravity-fed columns.

The experience of the French pilot plant used to obtain design information for the full-scale plant at Marcoule is very fully reviewed in P1172.[53]

However, the papers which were of most importance were again from the United States. Thus P516[54] reviewed experience on a variety of equipment in a Hanford pilot plant facility—instrumentation and decontamination for maintenance are particularly discussed. Paper 1930[55] gives a detailed account of the development of mechanical dejacketing devices for dealing with the Shippingport PWR fuel and also discusses chemical methods for removing Al and Zr cans. There is then a very useful discussion of methods of dissolving a large variety of alloys and ceramic fuels.

Fig. 3 Flow diagram for primary separation process.
1. Rod dissolver. 2. Cooler. 3. Feeder. 4. Column 1. 5. Feeder. 6. Neutraliser. 7. Reducer. 8. Feeder. 9. Column 2. 10. Feeder. 11. Column 3. 12. Evaporator. 13. Cooler. 14. Cooler. 15. Oxidiser. 16. Vacuum transfer. 17. Break vessel. 18. Vacuum transfer. 19. Feeder. 20. Column 4. 21. Feeder. 22. Column 5. 23. Batch tank. 24. Evaporator.



The most important advance in solvent extraction was reported in P519[56] on temperature effects in TBP processes. Since the complex labile species formed by many fission products (especially the acid earths and ruthenium) undergo slow changes, for example, by hydrolysis, an increase in temperature will hasten the changes in the direction of that being removed, and hence improve decontamination. Best results were obtained in the TBP system by operating a dual-temperature scrub section in the first extractor (first 16 stages at 30° C, last 12 stages at 70° C) and by operating the second extractor entirely at 70° C; the decontamination of the plutonium product was improved 100 times, and of the uranium product nearly 1,000 times. (See Fig. 4 for effect on uranium process.)

The technique of waste back-cycling as dis-

Continuing Chemistry and Processing

cussed in P2049[57] is also likely to prove very useful and lead to substantial economies in waste processing. Aqueous wastes from the purification cycles are used as scrub liquors in the earlier stages, and so on back down the plant, evaporating if necessary to adjust volume or acidity. By incorporating this idea and the dual-temperature extraction, very substantial further improvements and simplification to existing processes could be made.

A pilot plant for processing irradiated thorium (uranium 233 is the product) is fully described in P536[58]. This "Thorex" plant at Oak Ridge, USA, used a TBP process in pulsed columns and each major piece of equipment was housed in an individually shielded cubicle, and each tank and column was fitted with jets to allow addition of decontaminating solutions. Thus very thorough decontamination of the whole plant was possible for equipment modification and this feature proved invaluable when modifications were needed to the plant.

Some background chemical engineering investigations were presented in a paper describing pulsed columns (P1173[59] France, P515[60] USA). Still others reported on chemical work in aid of the design of such plants, for example P144[61] (Sweden) discussing the use of silica gel absorption techniques for separation, P2100[62] (Czechoslovakia), the use of methyl cyclohexanone as an extractant for uranium, and it is understood that Norway is investigating a three step method for recovery of plutonium from irradiated uranium using first TBP kerosine, then absorbent silica gel, and finally ion exchange.

A Russian paper (P2216[63]) showed from experiments with a mixture 85/15 of dibutyl ether and carbon tetrachloride that it would be possible to devise a process with good yield and good separation factors between uranium and plutonium, but the decontamination from fission products does not appear to be as good as with other solvents. The advantage of the system is the lessened fire risk.

Processing of Enriched Uranium.—The scale of operations (kilograms instead of tonnes), necessary to avoid the accumulation of a critical mass in solution, and the higher level of activity, make the plants for processing enriched uranium fuel considerably different from the large plants discussed in the last section. Notable plants described are those at Dounreay (P82[64]), Idaho (P526[65]) and Oak Ridge (P536[58]), which have been built to process the fuel elements from high-flux reactors which normally use uranium enriched to at least 50 per cent uranium 235, frequently as an aluminium alloy (see V. S. Crocker, "Research Reactors," in the present series, ENGINEERING, page 662, 21 November, 1958). A process based on TBP now seems favoured, and small mixer settlers to be used generally as contractors. The high burn-up of the fuel and the short cooling times required mean that the radiation level in the solvent is such (1,000 curies per litre) as to lead to appreciable degradation, and unfortunately the products (mono- and di-butyl phosphate) cause retention of uranium and poor recovery. Rigorous washing of the solvent before re-use in Holley-Mott mixer settlers, was found at Dounreay to overcome the difficulty. The flow diagram for the Dounreay plant is shown in Fig. 5.

The Idaho plant processes the fuel from the submarine Nautilus. A special head-end process is used, first to dissolve the zirconium bearing fuel elements in HF, followed by addition of aluminium to complex the fluoride ion; this pretreatment then allows extraction by a TBP process.

The avoidance of criticality in dissolver and mixer settler vessels is considered in two United States papers (P427[66], 518[67]). These favour control by geometry, that is to say, by provision of vessels of such shape and so disposed in relation to others that they may safely contain any concentration and any mass of fissile material in solution. Thus cylinders of very small diameter, however long, cannot be made critical nor can very thin slab tanks, owing to neutron leakage from the large surfaces (see Fig. 6). Where "Eversafe" vessels cannot be designed procedures are recommended for administrative control by limiting batches by mass and concentration.

Processing Plutonium.—Several United States papers discussed possible methods for processing plutonium bearing fuels. P530[68] compares the precipitation, ion exchange and solvent extraction routes. This last was found best, especially using a secondary amine as extractant. The amine extraction process is also the subject of P544[69] and ion exchange of P520. Pyrometallurgical methods are however favoured in P1830[70] and 529[71]. No reactor so far uses plutonium for enrichment of its regular fuel charge and these papers must be regarded as exploratory only. Experimental fuel elements with plutonium as the main fissile element have however been tested in both MTR and NRX, and the Dounreay and Enrico Fermi Fast Reactors will irradiate prototype fuel elements so that pilot plants are likely to be required fairly soon.

Non-Aqueous Processing.—Interest in non-aqueous methods continues, although the only plant actually being constructed is that for reprocessing EBR II fuel pins (P541[72]). This is on a pilot-plant scale and will be run in conjunction with the Experimental Breeder Reactor itself. The facility will test out the proposed process which is to purify by melt refining—volatile fission products are distilled out of the metal, and those elements forming oxides more stable than UO_2 form a slag layer by reaction with the zirconium oxide crucible, or with oxygen impurity in the argon atmosphere; the less stable elements are not removed (niobium, molybdenum, technetium, ruthenium, rhodium and palladium) but these if anything improve the radiation stability and metallurgical properties of the fuel. Additional fuel material will be added to the crucible, and the new sets of fuel pins cast. All operations will of course be carried out by remote control; and the crucial points to be tested concern the overall yield, and the size of the recovery process needed for drosses and crucibles. Further papers on development work are P538[73] and 1795[74] (both USA), and P32[75] (UK). The application to plutonium

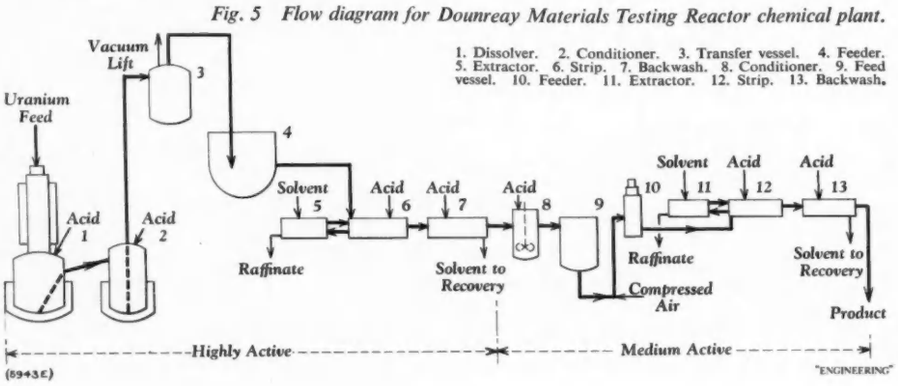


Fig. 5 Flow diagram for Dounreay Materials Testing Reactor chemical plant.

1. Dissolver. 2. Conditioner. 3. Transfer vessel. 4. Feeder. 5. Extractor. 6. Strip. 7. Backwash. 8. Conditioner. 9. Feed vessel. 10. Feeder. 11. Extractor. 12. Strip. 13. Backwash.

Fig. 4 Effect of temperature on uranium process.

(P529[71]) is mentioned above.

The other dry method which has been investigated for some years is the fluoride volatility process (P539[76]). A small pilot plant at the Argonne National Laboratory has been used to dissolve fuel alloys in liquid bromide trifluoride, and to purify the evolved UF_6 by distillation; remarkable decontamination factors are obtained in a short column (P2388[77]). In another version the fuel is first dissolved in a molten sodium fluoride—zirconium fluoride bath, and the UF_6 then formed by passage of fluorine. Needless to say, the choice of materials to withstand corrosion by F_2, UF_6, molten fluorides, or BrF_3, is not easy. The same process could be applied to the processing of fused-salt reactor fuel, and this has been tested at Oak Ridge very successfully in a small pilot plant (P535[78]). Russian laboratory experiments applying these techniques to U-Pu alloys are reported in P2253.[79]

Heavy Element Chemistry

Production of Heavy Elements.—The recovery of substantial (greater than gram) quantities of the elements protactinium, neptunium and americium from waste products (the first of uranium ore processing, the second of irradiated fuel processing and the last in purification of plutonium which has been allowed to stand) is reported in P1458[80] (UK) and P537[81] (USA). These gramme quantities have permitted the preparation of the metal, various oxides and fluorides and enabled the general inorganic chemistry of these elements to be greatly extended (see below).

The separation of curium (Cm^{242}) in 400 mg quantities (1,000 curies) from irradiated americium is described in P1883[82]—the intense activity causes bubbling of solutions and prevents precipitation processes from working, and also destroys organic solvents and plastics. The separation and purification processes must be remotely controlled and ion exchangers were used with dilute solutions at low bed loading.

The production of trans-curium isotopes by neutron irradiation of plutonium or americium or by heavy-ion bombardment is discussed in P825.[83] These essentially "weightless" quantities are separated by ion exchange, and fast chemistry techniques are required in order to separate and detect radiochemically short-lived activities; often less than five minutes is taken from end of bombardment to the start of counting. It was in this way that the elements mendelevium and nobelium were identified.

Properties of the Heavy Element Oxides.—Neptunium oxides are described in P304[84] (UK)—NpO_2 does not take up interstitial extra oxygen as PuO_2 and UO_2, but is like ThO_2. It is the most stable form and Np_3O_8 converts to NpO_2 on heating in air.

Work on uranium and plutonium oxides relevant to their use as reactor fuels is discussed in P26[85] (UK). The oxygen-oxide equilibria, and the application of the diagrams to sintering, to compatibility with oxidising coolant gases (for example, CO_2) and to phase changes in mixed oxides (solid solutions) are very fully

discussed. The PuO_2-O diagram is also given in P701.[86]

Heavy Element Halides.—Neptunium hexafluoride has been prepared on the gramme scale and is more volatile than UF_6 (P942[87]). Curium tetrafluoride has been prepared (using the isotope Cm^{244}) being the first tetravalent compound known. Later CmO_2 was prepared and also the metal (P224[88]).

The vapour pressure of AmF_4 has been measured (P2127 USSR[89]).

Solution Chemistry.—Several papers dealt with solution chemistry, P2127[89] (USSR), P941[90] (USA), P2247[91] (USA), P304[84] (UK). The most interesting feature is that the diversity of charges and configurations of the ions makes possible kinetic studies of every type and can thus yield valuable information on the mechanisms of inorganic reactions. These include isotope exchange reactions, the disproportionation reactions in which balancing valency changes occur spontaneously, and the autoreduction reaction due to reaction products of radiation on water. Thus Am(VI) solutions are reduced at a rate of several per cent per hour by the products of its own alpha radiation.

Reactor Chemistry

Reactor chemistry is a growing field and includes chemical work on the effects of irradiation on corrosion, oxidation and similar compatibility phenomena, and also work on the use of radiation to promote desirable chemical reactions.

In the first category maybe put P303[92] (UK), which discussed in detail the chemical reactions between carbon dioxide and graphite under

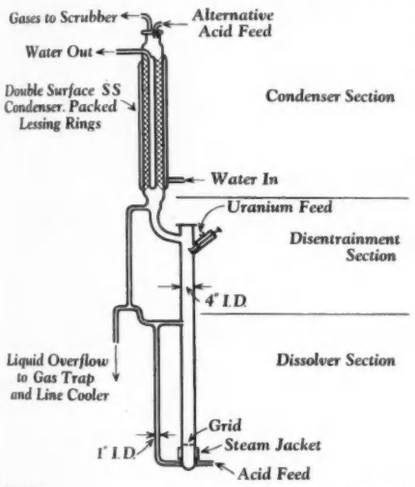


Fig. 6 Arrangement of Eversafe Dissolver (capacity 15 litres) used at the Dounreay Experimental Reactor Establishment.

reactor conditions. It shows that high-energy radiation has a profound effect on the chemistry of the CO_2/graphite system, but that these radiation-induced processes do not present any operational problems in reactors of the Calder Hall type. The essential rate controlling reaction occurs in the gas phase but it is not yet known what the active species is. Corrosion and radiation effects on the water system of water-cooled reactors were the subject of P410[93] (USA) and P1169[94] (France), and in boiling reactors in P946[95] (USA).

Sodium technology is discussed in P2291[96] (USA), P2194[97] (USSR) and P25[98] (UK), while P270[99] (UK) discusses liquid-metal technology more generally and included bismuth systems.

Also included here are chemical studies of possible liquid fuels, either in aqueous solution or in fused salts. Little new was given on the homogeneous aqueous systems (P46[100]), but there were two interesting papers on the chemistry of fused-salt reactor fuels (P448[101], P940[102]), such as were used in the Oak Ridge Fused Salt Reactor. Corrosion problems were treated in P1900[103].

In the second category it is clear that only very tentative attempts have been made as yet to find methods of applying directly the energy of fission-fragment recoil to industrial chemical processes. P76[104] (UK) showed that the most promising reactions to investigate were for nitric acid or hydrogen production.

REFERENCES

[1] Experiments Relating to the Possible Production of an Oxidising Acid Leach Liquor by Auto-Oxidation for the Extraction of Uranium, Geneva Conference P1116 Union of South Africa (1958).
[2] A Review of the Chemical Methods for the Determination of Uranium in Ores, Residues, and Products Arising During Processing, Geneva Conference P1117 Union of South Africa (1958).
[3] Extraction of Uranium from Acid Leach Pulps by Jigged-Bed Ion-Exchange, Geneva Conference P1096 Australia (1958).
[4] Some Variations of Uranium-Ore Treatment Procedures, Geneva Conference 22, Canada (1958).
[5] Canadian finishing Practice in the Production of Uranium Trioxide by Solvent Extraction with Tributyl Phosphate, Geneva Conference P22. Canada (1958).
[6] Special Problems Arising in Connection with the Production of Uranium Metal and Uranium Compounds, Geneva Conference P1001 W. Germany (1958).
[7] On a Process for Recovering Uranium from Japanese Ore, Geneva Conference P1361 Japan (1958).
[8] Chemical Processing of Uranium Ores in Hungary, Geneva Conference P1719 Hungary (1958).
[9] The Chemical Treatment of Uranium Ores in France, Geneva Conference P1254 France (1958).
[10] The Use of Lime as a Concentrating Agent for Uranium, Geneva Conference P1255 France (1958).
[11] Lixiviation Oxydante des Pechblendes et Précipitation de l'Uranium par l'Hydrogène, Geneva Conference P1256 France (1958).
[12] Préparation de Tétrafluorure d'Uranium à Partier d'UO_3 ou de Sel d'Uranyle, Geneva Conference P1259 France (1958).
[13] Progrès dans la Fabrication de l'Uranium le Cycle du Fluorure Double, Geneva Conference P1260 France (1958).
[14] Complex Utilisation of Uranium Ores, Geneva Conference P2064 USSR (1958).
[15] Recovery of Uranium from the Malargue Mendoza Mineral by Ionic Exchange, Geneva Conference P1553 Argentina (1958).
[16] Application of the Uranous Phosphate Method to the Recovery of Uranium from the Argentine Mineral of Malargue, Mendoza, Geneva Conference P1554 Argentina (1958).
[17] Recovery of Uranium from Ores by Direct Leaching with Organic Solvents, Geneva Conference P496 USA (1958).
[18] Pretreatment of Uranium Ores, Geneva Conference P513 USA (1958).
[19] The Role of Process Development in Western United States Uranium Procurement, Geneva Conference P545 USA (1958).
[20] Recovery of Uranium from Chattanooga Shale, Geneva Conference P1024 USA (1958).
[21] Recovery of Uranium from Phosphate Ores, Geneva Conference P1066 USA (1958).
[22] Amine Salts as Solvent Extraction Reagents for Uranium and Other Metals, Geneva Conference P510 USA (1958).
[23] The Excer Process —An Aqueous Method for Production of Pure Uranium Tetrafluoride from Crude Uranium Sources, Geneva Conference P506 USA (1958).
[24] Production of Refined UF_6 from Ore Concentrates by Fluidisation and Fractional Distillation Techniques, Geneva Conference P1552 USA (1958).
[25] The Development of a High Capacity, Continuous Process for the Preparation of Uranium Hexafluoride from Uranium Oxides and Ore Concentrates, Geneva Conference P525 USA (1958).
[26] The Anion Exchange of Metal Complexes, Geneva Conference P1605 Israel (1958).
[27] A Method for the Reduction of Uranium is Phosphoric Acid, Geneva Conference P1608 Israel (1958).
[28] Pilot Plant Study on the Purification of Uranium Concentrates by Means of Extraction with Tributyl Phosphate, Geneva Conference P1413 Spain (1958).
[29] Method for Direct Fluoridation of Uranium Compounds, Geneva Conference P1418 Spain (1958).
[30] Studies on the Preparation of Pure Uranium Tetrafluoride from Crude Sodium Diuranate, Geneva Conference P1668 India (1958).
[31] The Flurex Process: a Wet Chemical Method for the Production of Uranic Fluoride Salts, Geneva Conference P534 USA (1958).
[32] A Moving Bed Reactor for the Production of Uranium Tetrafluoride, Geneva Conference P1015 USA (1958).
[33] Preparation of Pure Uranium Metal in the CNRN, Geneva Conference P1399 Italy (1958).
[34] Improvements Made in the Methods of Purifying Uranium Compounds and in the Production of Uranium Metal at the Bouchet Plant, Geneva Conference P1252 France (1958).
[35] Refining of Uranium Concentrate and Production of Uranium Oxide and Metal, Geneva Conference P179 Sweden (1958).
[36] Reducción Electrolítica del Ion UO_2 con Cátodo de Mercurio y su Applicación a la Obtención de Fluoruros de Uranio, Geneva Conference P1414 Spain (1958).
[37] The Reduction of Uranium Hexafluoride by Carbon Tetrachloride, Geneva Conference P300 UK (1958).
[38] Continuous Processes for the Direct Reduction of Uranium Hexafluoride to Uranium Tetrafluoride of High Purity and Density, Geneva Conference P523 US (1958).
[39] Current Manufacturing Processes Used in the United States for Mass Production of UF_6 from Purified UO_3, Geneva Conference P1840 USA (1958).
[40] Canadian Development Work with Moving Bed Reactors for Reduction of Uranium Trioxide and Hydrofluorination to Uranium Tetrafluoride for Subsequent Production of Metal, Geneva Conference P229 Canada (1958).
[41] Fluidisation Techniques as Applied to Reactor Fuel Processing, Geneva Conference P542 USA (1958).
[42] Fluidised Bed Conversion of Fuel Processing Wastes to Solids for Disposal, Geneva Conference P1922, USA (1958).
[43] Recently Developed Processes for the Extraction and Purification of Thorium, Geneva Conference P1526 UK (1958).
[44] Les Problèmes de la Préconcentration des Minerais d'Uranium par Voiephysique, Geneva Conference P1257 France (1958).
[45] Production of Nuclear Grade Thorium Compounds, Geneva Conference P1670 India (1958).
[46] Investigations on Alkaline Methods for Monazite and Zircon Processing, Geneva Conference P2154 USSR (1958).
[47] Thorium Metal Production by a Chlorination Process, Geneva Conference P1468 UK (1958).
[48] A Carbide-Iodide Process for High Purity Thorium, Geneva Conference P1098 Australia (1958).
[49] The Chemical Processing of Irradiated Fuels from Thermal Reactors, Geneva Conference P307 UK (1958).
[50] Problems Raised by the Construction of the Plutonium Extraction Plant: Some of the Solutions Applied at Marcoule, Geneva Conference P1174 France (1958).
[51] Some Peculiarities in Treating Irradiated Fuel Elements at the First Atomic Power Station in the USSR, Geneva Conference P2182 USSR (1958).
[52] The Joint Establishment for Nuclear Energy Research Reprocessing Pilot Plant, Geneva Conference P585 Norway (1958).
[53] The Processing of Irradiated Uranium. Results of the Operation of the Fontenay-aux-Roses Pilot Plant, Geneva Conference P1172 France (1958).
[54] Operating Experience in a "Hot" Solvent Extraction Plant, Geneva Conference P516 USA (1958).
[55] Dissolution and Feed Preparation for Aqueous Radiochemical Separation Processes, Geneva Conference P1930, USA (1958).
[56] Temperature Effects on TBP Solvent Extraction Processes, Geneva Conference P519 USA (1958).
[57] Some Problems of Working Zirconium and its Alloys, Geneva Conference P2049 USSR (1958).
[58] Operating Experience with Two Direct-Maintenance Radiochemical Pilot Plants, Geneva Conference P536 USA (1958).
[59] Étude des Colonnes à Pulsations à l'Aide du Système Nitrate d'Uranyle-Acide Nitrique-Eau-Tributylphosphate, Geneva Conference P1173 France (1958).
[60] Improved Pulsed Solvent Extraction Column Cartridges, Geneva Conference P515 USA (1958).
[61] Separation of Plutonium from Uranium by Partition between an Organic Solvent and a Stationary Water Phase Adsorbed on Silica Gel, Geneva Conference P144 Sweden (1958).
[62] Processing of Irradiated Fuels, Geneva Conference P2100 Czechoslovakia (1958).
[63] Separation of Uranium and Plutonium from Fission Products by a Mixture of Dibutyl Ether and Carbon Tetrachloride, Geneva Conference P2216 USSR (1958).
[64] Chemical Processes at UKAEA Works, Dounreay, Geneva Conference P82UK (1958).
[65] Zirconium Alloy Fuel Reprocessing, Geneva Conference P526 USA (1958).
[66] Nuclear Safety in the Unirradiated Processing Phases of Enriched Uranium Fuel Cycles, Geneva Conference P427 USA (1958).
[67] Critically Safe Equipment for Aqueous Separation Processes, Geneva Conference P518 USA (1958).
[68] Aqueous Decontamination of Plutonium from Fission Product Elements, Geneva Conference P530 USA (1958).
[69] Tertiary Amine Extraction of Plutonium from Nitric Acid Solutions, Geneva Conference P544 USA (1958).
[70] Recent Developments in Plutonium Processing in the United States, Geneva Conference P1830 USA (1958).
[71] Pyrometallurgical Purification of Plutonium Reactor Fuels, Geneva Conference P529 USA (1958).
[72] The Pyrometallurgical Process and Plant for EBR-II, Geneva Conference P451 USA (1958).
[73] Developments in Melt Refining of Reactor Fuels, Geneva Conference P538 (USA (1958).
[74] Developments in Pyrometallurgical Processing, Geneva Conference P1795 USA (1958).
[75] Processing of Reactor Fuels by Liquid Metals, Geneva Conference P32 UK (1958).
[76] Recent Developments in Fluoride Volatility Processing of Reactor Fuels, Geneva Conference P539 USA (1958).
[77] Fluoride Volatility Processes for Spent Reactor Fuels, Geneva Conference P2388 USA (1958).
[78] Recovery of Uranium from Highly Irradiated Reactor Fuel by a Fused Salt—Fluoride Volatility Process, Geneva Conference P535 USA (1958).
[79] Dry Method for Regenerating Irradiated Uranium, Geneva Conference P2253 USSR (1958).
[80] The Extraction of Actinide Elements from Wastes, Geneva Conference P1458 UK (1958).
[81] Americium and Neptunium Recovery Processes, Geneva Conference P537 USA (1958).
[82] The Production and Chemical Isolation of Curium 242 in Thousand-Curie Quantities, Geneva Conference P1883 USA (1958).
[83] Methods of Production and Research on Transcurium Elements, Geneva Conference P825 USA (1958).
[84] The Chemistry and Metallurgy of Neptunium, Geneva Conference P304 UK (1958).
[85] The Actinide Oxides, Geneva Conference P26 UK (1958).
[86] Thermodynamics and Phase Relationships for Plutonium Oxides, Geneva Conference P701 USA (1958).
[87] Some Recent Studies with Hexafluorides, Geneva Conference P942 USA (1958).
[88] Uranium Deposits of Bancroft Region, Ontario, Geneva Conference P224 Canada (1958).
[89] The Investigation on the Americium Chemistry, Geneva Conference P2127 USSR (1958).
[90] Reaction Kinetics of the Actinide Elements, Geneva Conference P941 USA (1958).
[91] Recent Advances in the Basic Chemistry of Plutonium, Americium and Curium, Geneva Conference P2247 USA (1958).
[92] Chemical Studies of Carbon Dioxide and Graphite under Reactor Conditions, Geneva Conference P303 UK (1958).
[93] Radioactivity Levels in Pressurised Water Reactor Systems, Geneva Conference P410 USA (1958).
[94] Tests on Dynamic Corrosion by Water Effect of the Passage of the Thermal Flux on the Corrosion Kinetics. Measurement of the pH in High Temperature Water, Geneva Conference P1169 France (1958).
[95] Water Chemistry in a Direct Cycle Boiling Water Reactor, Geneva Conference P946 USA (1958).
[96] Sodium Technology for Nuclear Power Plants, Geneva Conference P2291 USA (1958).
[97] On the Corrosion Resistance of Some Materials in Sodium and Lithium, Geneva Conference P2194 USSR (1958).
[98] Compatibility of Reactor Materials in Flowing Sodium, Geneva Conference P25 UK (1958).
[99] Liquid Metal Fuel Technology, Geneva Conference P270 UK (1958).
[100] Some Chemical Problems of Homogeneous Aqueous Reactors, Geneva Conference P46 UK (1958).
[101] Chemical Aspects of Molten Fluoride Reactors, Geneva Conference P448 USA (1958).
[102] The Chemistry of Fused Salts, Geneva Conference P940 USA (1958).
[103] Theory and Application of Burnable Poisons, Geneva Conference P1900 USA (1958).
[104] The Possibility of the Direct Application of Fission Recoil Fragment Energy to Industrial Chemical Processes, Geneva Conference P76 UK (1958).

Atomic Review

Active Agents

AGENCIES dedicated to international co-operation in the peaceful applications of atomic energy continue to be active; some further details of their work are reported below. Previous comments on these bodies have appeared in Atomic Review on 2 January this year, and in 1958 on 19 and 26 December, 21 November, 10 and 17 October, 29 August and 22 August, when a list of previous references was published.

Membership of European Organisations

The accompanying table lists organisations concerned with nuclear energy in Europe, indicating their membership. Except for the Federal Republic of Germany all countries named are members of the United Nations. In addition, all countries except Ireland are members of the International Atomic Energy Agency (IAEA), which also includes some 40 other, mostly non-European, members. The letter M indicates membership; A represents an associate; and Me a member through Euratom.

—	ENEA			Euratom	European Organisation for Nuclear Research (CERN)	European Atomic Energy Society	Membership of Council of Europe
	Membership	First Projects					
		Eurochemic	Halden				
Austria	M	M	M		M	M	M
Belgium	M	M	Me	M	M	M	M
Denmark	M	M	M		M	M	M
France	M	M	Me	M	M	M	M
F.R. of Germany	M	M	Me	M	M	M	M
Greece	M				M		M
Iceland	M						M
Ireland	M						M
Italy	M	M	Me	M	M	M	M
Luxembourg	M		Me	M			M
Netherlands	M	M	Me	M	M	M	M
Norway	M	M	M		M	M	M
Portugal	M	M					
Sweden	M	M	M		M	M	M
Switzerland	M	M	M		M	M	
Turkey	M	M					M
United Kingdom	M		M		M	M	M
Spain	A					M	
Yugoslavia					M	M	
Canada	A						
United States	A						

IAEA Advisory Committee

The board of governors of the International Atomic Energy Agency have appointed seven eminent scientists to serve on the Agency's scientific advisory committee. The seven members, nominated by director general Sterling Cole and appointed by the board are: Professor H. J. Bhabha (India) Sir John Cockcroft (United Kingdom), Professor V. S. Emelyanov (USSR), Professor B. Goldschmidt (France), Professor B. Gross (Brazil), Professor W. B. Lewis (Canada), and Professor I. I. Rabi (United States).

UK-Euratom Agreement Signed

An agreement for co-operation between the United Kingdom and the European Atomic Energy Community (Euratom) was signed on 4 February, during a three-day visit which the Euratom Commission has made to the U.K.

Starting Euratom

Since the formation of the European Atomic Energy Community, generally known as Euratom, on New Year's day, Nuclear products have been free to circulate in the Six countries without tariff or quota restrictions. A common tariff against the entry of nuclear goods and products from outside countries including Britain has also come into force. Under this tariff, fissile materials pay no duty, but nuclear materials and machinery pay duties up to 12 per cent. Some duties will not come into operation during the first years of the Common Market. For the most important item—complete nuclear reactors or parts thereof—the duty fixed at 10 per cent has been suspended until 1 January 1962. No duty will be payable on the following ores, fissile materials and raw materials: uranium ores with a content of natural uranium exceeding 5 per cent by weight; pitchblende with a content of natural uranium exceeding 5 per cent by weight; uranium oxide; inorganic compounds of natural uranium other than uranium oxide and uranium hexafluoride; organic compounds of natural uranium; natural uranium unwrought or wrought; alloys containing plutonium; organic or inorganic compounds of uranium enriched in organic or inorganic compunds of uranium 235; organic or inorganic compounds of uranium 233; thorium enriched in uranium 233; organic or inorganic compounds of plutonium; uranium enriched in plutonium; uranium enriched in uranium 235; alloys containing uranium enriched in uranium 235 or uranium 233; plutonium; uranium 233; uranium hexafluoride; monazite; thorium ores with a thorium content exceeding 20 per cent by weight; urano-thoianite containing more than 20 per cent of thorium; thorium unwrought or wrought; and thorium oxide.

Stresa Conference on Industrial Prospects

An OEEC conference on industrial prospects in nuclear energy is to be held in Stresa, Italy, from 11 to 14 May. The conference is being sponsored by the Council of European Industrial Federations, a body on which Britain is represented by the Federation of British Industries. The object of the meeting is to evaluate the commercial prospects for industry in the nuclear energy field, the probable markets for materials and equipment and the amount of investment needed and the likely return on it. Five main subjects are listed for study. They are: (1) economics of nuclear power, especially in comparison with conventional power; (2) the financing of national and interational nuclear energy programmes; (3) the working out of atomic law as applied to nuclear materials, the communication of technical information and the problems of management and sales organisations in the nuclear field; and (5) the problems of forecasting the market possibilities for materials, equipment and instruments. Speakers will be invited from the United States and Canada as well as from industrial and governmental organisations in the OEEC countries. During the conference delegates will visit the Italian Nuclear Research Centre at Ispra.

Nuclear Prize

The Council of Europe sponsors a programme of cultural activities including a biennial competition in advanced European research. The theme chosen for the first award is the " consequences of the use of nuclear energy for the European mode of life." The work submitted must be of a high academic standard and represent an original contribution to the subject. It must not have been previously published. The prize is the round sum of one million French francs, presumably of the current variety. Theses may be written in one of six languages—English, French, German, Italian, Dutch and Spanish. Entries must be typed and six copies submitted by 31 December, 1960. The Council of Europe is selecting a jury to award the prize, and it will take responsibility for publishing the winning entry. Readers requiring any further information should write to the Secretariat-General, Council of Europe, Strasbourg, France.

Boiling Heavy Water Reactor at Halden

It is understood that the Halden boiling heavy water reactor, which is to be operated jointly by members of the OEEC European Nuclear Energy Agency, is due to diverge towards the end of March. Last June representatives of a number of European countries and Euratom concluded an agreement for the joint operation of the 10 MW experimental reactor. Representatives from Austria, the Danish Atomic Energy Commission, the Euratom Commission (on behalf of the six countries, members of the European Atomic Energy Community) AB Atomenergi of Sweden, Switzerland and the United Kingdom Atomic Energy Authority agreed to join with the Norwegian Institute for Atomenergi—the builders and owners of the reactor—in carrying out a joint programme of research and experiments over a three-year period beginning on 1 July, 1958. The reactor, situated 120 km south of Oslo, is the only boiling water reactor in Europe and the first heavy water boiling reactor in the world. A budget of the order of $4 million was envisaged for the joint programme, designed to study the scientific and technical problems related to this reactor type. An international committee will approve the joint programme and a technical group will supervise its execution. The Norwegian Institute will carry out the programme with a staff recruited from the participants.

Notes and News

Criticalities

In addition to the Halden experimental boiling heavy water reactor, which is expected to diverge towards the end of March, the following reactors are due to become critical in the near future: both Herald, the 5 MW experimental light water cooled and moderated reactor at Aldermaston, and the HTGC (high-temperature gas-cooled) reactor at Winfrith Heath should diverge within the next two or three months; and the Dounreay fast breeder reactor on 1 April.

NPPC Chairman

Mr. R. Edwin McAlpine has been elected chairman of the Nuclear Power Plant Company in succession to Sir Claude D. Gibb.

Quotations for Uranium Oxide

Uranium oxide has been offered to the International Atomic Energy Agency by the Union of South Africa at a price of £3 8*s* per lb; and by the Societé Générale des Minerais, of Belgium, at $8 per lb of oxide contained in 80 per cent concentrates.

Joint Nuclear Company

Saunders-Roe Limited have become increasingly interested in certain specialised fields of nuclear engineering and during the last twelve months close contact has been maintained with Nuclear Enterprises (GB) Limited of Edinburgh. As a result of this association the two companies announce the formation of a new jointly owned company, Saro-Nuclear Enterprises Limited, with its head office at 53, Parliament Street, London, S.W.1. The activities of this company will cover the fields of applied irradiation and the application of isotopes to industrial processes.

Grenoble Atomic Energy Centre

An atomic energy research and study centre has been opened at Grenoble, where it will be linked with the university.

Workable Yttrium

Yttrium, a material characterised by a low thermal-neutron cross-section, but usually extremely brittle, has been produced by the United States Bureau of Mines in an easily worked form. This effect has been achieved by increasing the purity of the metal and in particular by reducing the oxygen content to 0·02 per cent. The melting point of yttrium is 1,550° C.

Marketing

Off to Sunny Lands

There has been a quickening of British industry's interest in exports. Recent news of foreign trips by senior executives suggests that winter sunshine is not all they seek, although the sunnier lands undoubtedly hold many attractions.

Sir Leonard Lord, Chairman of the British Motor Corporation, left England on 22 January for a tour of his company's factories and distributors in South Africa. His trip was described by BMC's public relations officer as the spearhead of " a new export policy." Sir Leonard himself spoke of BMC " embarking upon their 1959 programme in a spirit of buoyant optimism " and stressed the importance of personal visits abroad to back up the introduction of new models. " Our top salesmen, designers and engineers," he said, " are travelling world-wide in an energetic drive to increase our exports and keep in touch with market conditions and designs and engineering developments." The technical objectives of such travel cannot be overstressed.

Lord Chandos has left for Latin America, where he will meet " Government and business leaders in Brazil, Venezuela, Mexico, Argentina and Chile," on behalf of Associated Electrical Industries. In Buenos Aires he will see work on the £30 million power station being built there by the British Thomson-Houston/International Combustion Limited partnership. Two other chairmen in sunny lands, Mr. Hamlyn M. Drake, head of Drake and Gorham (electrical contracting and switchgear manufacturers) is visiting South, Central and East Africa to examine the possibilities there for his company's plant. One of his co-directors, Mr. Humphrey Jones, has joined him there and two others are visiting India and Pakistan. Mr. K. G. Sinclair, chairman of the Griffin and George group of companies of Alperton, who manufacture scientific instruments, is touring India, Singapore, Australia and New Zealand, until the end of March.

The itinerary of Mr. L. R. H. Bell, who is visiting the Caribbean and some central American countries on behalf of the Chamberlain Group of Companies, has been published and widely circulated. Mr. Bell indicates when and where he will be available. His tour lasts two months and covers the appointment of additional representatives for the group. The managing director of Sciaky Electric Welding Machines Limited, one of the leading makers of resistance welding plant in the world, is visiting South Africa, Australia, New Zealand, Ceylon and India. His primary purpose is " to visit the company's agents and to extend the field of Sciaky activities in these countries, and to study the progress made in fabricating methods generally." This considerable activity abroad of leading British industrialists augurs well for the country's export performance.

Come to the Fair

Czechoslovakia is holding her first international trade fair from 6-20 September in Brno, with the main emphasis on engineering products. The latest information bulletin on the subject underlines the world reputation of " Czechoslovak machine tools, machinery equipment for various industries, tractors, motor cycles, cars and trucks."

Various steps are being taken to make the Brno fair attractive to exhibitors and visitors from other countries. They will be entitled to a 50 per cent reduction when travelling on Czechoslovak railways and 20 per cent reduction on most of western Europe's railways. Similar reductions are offered for group travel on Czechoslovak airlines. Applications should be sent not later than five months before the fair opens (i.e. by mid-April), to Brno Trade Fair, Branch Office, 17 Václavské nám., Prague 3.

Indian Bridgeheads

News that the British Insulated Callender's Cables Limited had been awarded a £2½ million contract by the Indian Railway Board for the design, supply and installation of 25 kV 50 cycle, single phase a.c. overhead equipment suggests that India is slowly overcoming her financial difficulties. The terms of the contract, however, indicate the country's great need to conserve currency. About 60 per cent of the total amount will be spent in Indian currency on materials manufactured locally and on native staff and labour.

BICC say that this order was obtained " against keen international competition " and it is therefore a useful indication of the Indian Government's thinking on the subject of import of capital plant and equipment. Little hope should be entertained of supplying anything to which local materials and labour can contribute. The correct policy for British firms is doubtless the setting up of local manufacturing companies to ensure that this is done.

The Owen Organisation have just formed a new company in Bombay, Mahindra Owen Private Limited, which will be engaged in the production and sale of " motor vehicle components and general-purpose trailers and chassis components." It will deal in all forms of medium and heavy pressings and assemblies for industry generally. The new company is jointly owned by the Owen Organisation and the Mahindra Group of Companies in India, who are already substantial manufacturers of engineering products, including motor vehicles, diesel engines, textile machines and lifts.

Packing Up

A course with an unusual emphasis on " how-to-do-it " techniques and procedures for up-to-date packaging and materials handling is being held by the Industrial Management Center, Lake Placid Club, New York, between 31 May and 13 June. This is the second in a series entitled " Annual Packaging Training Conference " and is organised by the director of the Industrial Management Center, James R. Bright, who conducts an annual materials handling course which in the past years has been attended by 200 people from 150 companies in 11 countries, including France and Britain.

The Packaging Training Course will consist of an integrated series of lecture-discussion sessions on various phases of packaging by leading authorities in their respective fields. They are aimed to enable the participant " to return to his plant prepared to put into practice many new ideas and improvements in the packaging area." Among the topics to be taken up are: material and container evaluation and design (cartons, set-up boxes, wood, wirebounds, fibre, metal, multi-wall, preservation and protection materials, shock and vibration theory and practice, strapping and tape); packaging systems and equipment (automatic and semi-automatic machinery conveyors, layout, mechanisation economies); research and control aspects of packaging (testing methods, laboratory planning, costs, quality, consumer acceptance); and organisational problems (co-ordination, traffic, new developments, organisation, improvement programmes, committees).

The course will be under the technical direction of Mr. R. Frank Weber, formerly with International Harvester Company. An illustrated brochure is available on application from Mr. James R. Bright, Industrial Management Center, 56B Robbins Road, Lexington, Massachusetts, USA.

Jaguar Leaps

The rise of Jaguar cars has once again been most marked in export markets. Total sales in 1958 were 44 per cent higher than in the previous year (1957) and export sales 47 per cent higher. Fifty-four per cent of all cars produced were exported. Sales to North America reached a record value exceeding $22 million and sales to the Continent of Europe were up by 42 per cent.

A number of makers have attempted to jump on the Jaguar band-waggon, with cars of similar performance and price range. Yet they have made little headway. The unique reputation of Jaguar for safe, high speed motoring can only be built up as they did, by a long run of successes in international racing and rally events. The fact that the world champion racing driver, Mike Hawthorn, had chosen a Jaguar 3·4 as his private car emphasises the quality of the product in the eyes of experts. His tragic death when his car hit a tree after a skid on a treacherous road underlines the dangers of high-speed motoring even by the world's best drivers in the world's safest fast cars.

French Quotation

Foreign participation in French fairs and exhibitions is limited by a series of bilateral quotas under which licences may be granted for goods exhibited. Amounts are laid down within the quota for different categories of goods. Unfortunately the size of the quota is small in comparison with the range of goods and number of importers. The Machine Tool Trades Association describe the size of allocations made under the quota as " in many cases derisory." This comment is made in a note to members of the Manufacturers' and Allied Trade Sections and others interested in the 6th European Machine Tool Exhibition. The note is based on information from the Commercial Department of the British Embassy in Paris.

There is no special heading in the " fairs " quota for machine tools. These fall within " miscellaneous tools " (£19,000), which includes all tools, and " miscellaneous electric and mechanical " (£45,000), which covers a wide range of goods. These figures will indicate how limited are the possibilities in comparison with the values involved at the exhibition. The method of allocating the quota is that the licences are allocated to French *importers* (not British exporters) during the exhibition year. A total figure of which each applicant is informed at the outset of the exhibition season is also given. The objects of this system are that each importer knows where he stands and can plan his exhibition policy in full knowledge of what he may expect out of the fairs quota.

The various other restrictions embodied in the detailed administrative arrangements for the quota are given in the MTTA's note.

Research and Development

SHAFT STABILITY IN GAS FILM BEARINGS

By V. H. BRIX, B.SC., A.C.G.I.
Principal Scientific Officer,
Ministry of Supply

The time is rapidly approaching now for a reappraisal of the problems of carrying high-speed rotors in modern pumps, compressors and turbines. Present-day bearings are already becoming as mandatory as gas turbine blades, nozzle guide vanes, etc. The conventional rolling type bearing, in which a number of discreet balls or rollers gyrate round hardened tracks, and carry loads by virtue of very great dimensional uniformity of the components, is about as fully developed as it can possibly be. Further improvements in high-speed bearings of this type can only be achieved if they could be manufactured from very esoteric materials, of exceptional hardness, strength and thermal stability. Again, such bearings can only be used if a new lubricant appears that is chemically and physically stable under the conditions under which so many of such bearings must be utilised, that is, temperatures of 200° C and upwards. Rolling bearings carry within themselves the seeds of their own destruction; for, each ball or roller undergoes marginally high surface contact stresses many times a second, and the life or reliability of the bearing is thereby limited. At the present time the manufacturing accuracy appears to have approached the limits comparable with the localised, repetitive, deflections in ball, roller or track.

The hydrodynamic gas film bearing, as described by Ford, Harris and Pantall[1], shows definite promise at this stage, because the gaseous lubricant does not, normally, break down at high temperatures; and the bearing itself is plain and smooth and is not subjected to high localised repeated stresses.

The obvious disadvantage of the gas film bearing, namely, the inherent weakness of the gas film, is not such a disadvantage as it might appear at first sight, for in high speed bearings the journal loads are usually due to the constant weight of the rotating components or, perhaps, a small multiple of the weight. Alternatively, loading may be " aerodynamic " and increases with speed of rotation. In this case the hydrodynamic gas bearing is able to meet this contingency because film stiffness increases with speed.

However, the inherent weakness of the gas film bearing is manifest in its tendency to cause shaft or rotor to " whirl " or to precess bodily within the bearing clearance. There is, therefore, great sensitivity to unbalance and to dynamic disturbances of various kinds.

In this article this particular problem is discussed. Experimental results are given which appear to reveal the nature of such whirling and possible methods of cutting it down. A simplified theory of whirling is advanced: the fact that the experiments reveal that it takes place at the same velocity as the spin of the shaft about its own axis allows a straightforward approach. It is assumed, at the outset, that the gas film behaves like a linear spring, and that the film reaction is in the same direction as the displacement of the shaft within the bearings. The shaft is also perfectly stiff. With the present state of our knowledge of the dynamics of rotating machinery, an approach such as this obviously commends itself, even if proved inadequate later by new results.

The experiments described were carried out on shafts and rotors for a high-speed gas circulator which was found to be inherently unstable at the outset. The design could not be changed, so that the experiments were designed to control the manufacturing parameters so as to make the best of the existing scheme. The aim in this article is to try and help to avoid repeating errors which were inevitable in the first attempts in this new venture. It is apparent that many difficulties might be circumvented in future projects if one or two design principles are observed. In many cases balancing shafts to accuracies as high as those, at present, incorporating rolling bearings at 30,000 r.p.m. upwards, may not be necessary.

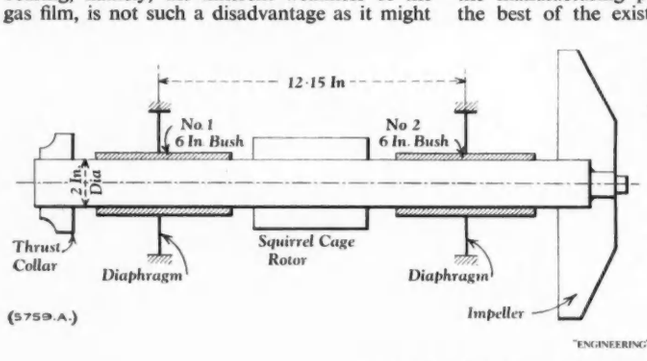
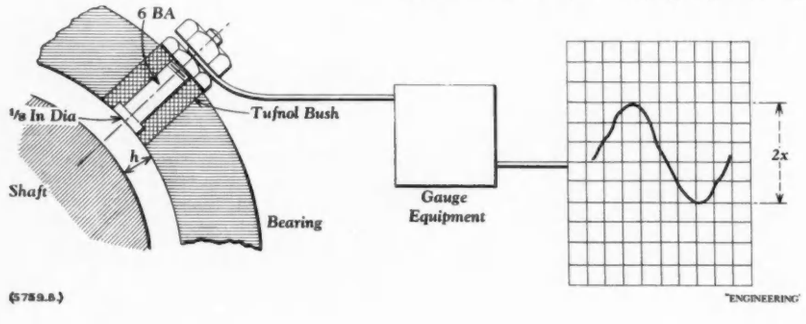


Fig. 1 Sketch of the test shaft, referred to in the text as shaft No. 1.

Fig. 2 Electrical probe in bearing, and oscilloscope trace taken while shaft is rotating and whirling.



SHAFT WHIRL MEASUREMENTS

The circulator shaft and rotor assembly was tested at various speeds on the mock-up rig illustrated in Fig. 1. Here, a 2 in diameter shaft is supported by two bronze bush type journal bearings, each 6 in long. The shaft was driven by the die-cast squirrel-cage rotor mounted between the bearings, the stator being energised by a three-phase variable frequency supply. The shaft carried a relatively large impeller at one end, and a plain thrust collar at the other. Each journal bush had electrical capacity probes made flush with the bore, as illustrated in Fig. 2. These probes were essentially small metallic surfaces acting as condensers, the distance between them and the surface of the shaft forming the " air gap " whose thickness, h, could be assessed by measuring the resulting changes in capacity for various relative positions of shaft within the bush. This method was advocated by Ford.[1]

The capacity of these probes ranged between 10 and 20$\mu\mu$ F, a very small magnitude, and required extensive magnification. This was accomplished with proprietary electronic gauging equipment, the capacities to be measured being connected to radio frequency circuits whose resonant frequencies were thereby modified. Resulting signals, suitably discriminated, emerged as direct voltages which could be observed on the screen of a cathode ray oscilloscope. They appeared on the Y axis, the X axis being a time base, suitably synchronised to the rotation of the shaft. Fig. 2 shows the kind of trace which appeared, and represents one complete revolution of the shaft as seen by one probe. The slight roughness represents the surface irregularities of the shaft to a magnified scale.

Figs. 3, 4, 5 and 6 are experimental graphs showing the radius of whirl of the shaft from its mean position, that is, some geometrical bearing centre line. The radius of whirl is seen to increase with rotational speed and tends to approach a critical condition at some resonant speed. The speed of whirl or precession was exactly the same as the rotational speed of the shaft in all cases. (We do not discuss the " half speed whirl " problem here.) In general, it was found that the whirl amplitude was not equal at the two bearings. This is not surprising, because the various masses were not uniformly distributed along the shaft.

By making an axial scratch on the shaft surface, at the same angular position in both bearings, it was found that the amplitude of whirl was in the opposite sense in the two cases, there being a phase difference of, approximately, 180° in the relative positions of the scratches, seen in the oscilloscope trace, with respect to the whirl trace. The shafts, therefore, whirled synchronously, generating a conical surface with apex somewhere between the bearings.

The amplitude of whirl was found to be

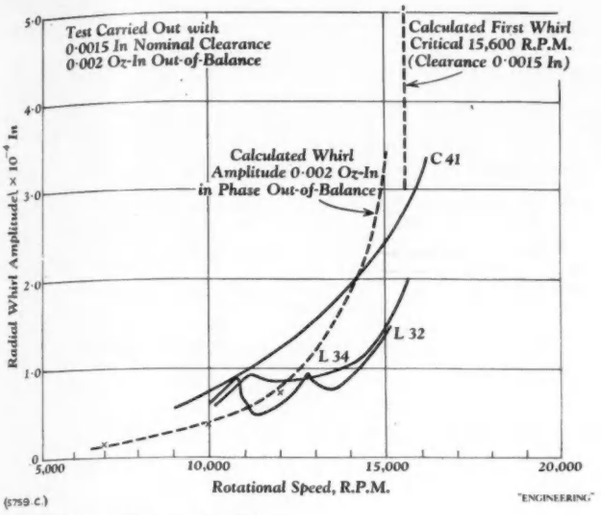


Fig. 3 The variation of whirl amplitude with speed for shaft No. 1.

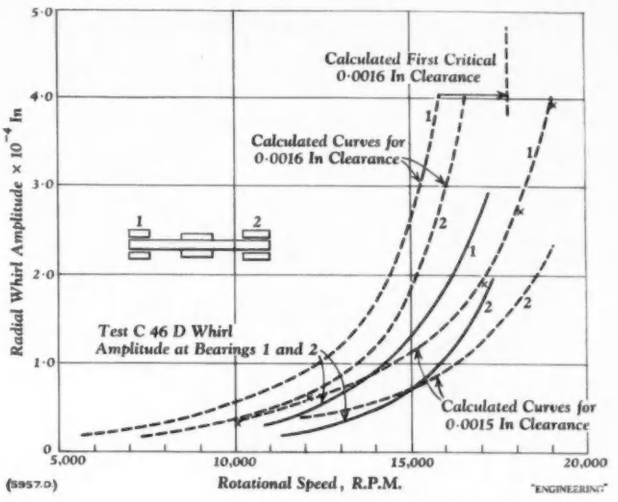


Fig. 4 Whirl amplitudes at bearings 1 and 2 (shaft No. 2).

great when the degree of balancing of the shaft was insufficient, that is, there were high residual unbalance moments.

DYNAMIC BALANCING

The necessity for accurate balancing was therefore evident at an early stage in the development. Residual unbalance figures of the order of 0·002 oz-in per bearing were found to be desirable because of the great tendency of the shaft to whirl at high amplitudes around its design speed of 15,000 r.p.m.

In itself, this degree of unbalance will result in a rotating force of only 2 lb at this speed, well within the capacity of the bearings, the gas film being able to sustain loads of more than 30 lb or so. The fact that the whirl amplitude corresponds to forces greatly exceeding that inherent in the residual unbalance of the shaft points to the resonant, or critical nature of the phenomenon.

A degree of residual dynamic unbalance of this order, 0·002 oz-in, corresponds to a difference of 0·000012 in between the position of the centre of gravity of the shaft and it's effective geometric axis of rotation. It is obvious that the conventional type of balancing machine, in which the shaft is supported in vee blocks or rollers, is quite inadequate for this sort of work, for the shaft surfaces cannot be made circular to within the accuracy demanded by the balancing machine. A shaft incorporating ovality to the extent of 0·00001 in, when rotated in vee blocks, displaces its centre of gravity while it is rotating in the machine to a degree commensurate with the residual unbalance required.

Gas bearings, in themselves, do not demand such high accuracy in manufacture, and it would appear ludicrous to have to achieve these limits just to suit conventional* balancing machines.

Dynamic balancing was therefore carried out in a machine in which the vee blocks were replaced by air bearings, in this case, half-bushes drilled with holes to form jets when supplied with compressed air. By using such a method, it is assumed that the geometric spin axis of the shaft, when being balanced, is the same as that when operating at the required conditions in the plant.

Fig. 7 shows the balancing machine which was developed for this purpose, the general method being to spin the shaft by a jet of compressed air, to a suitable speed, and to alternately reduce the unbalance at each bearing by trial and error applications of plasticine. This is, of course, adequate for laboratory use. There is no reason why the balancing operations could not be done fully automatically (as are the rotors of fractional horse-power motors in the USSR) where justified by demand.

* "Conventional" machines available when the experimental work was in progress.

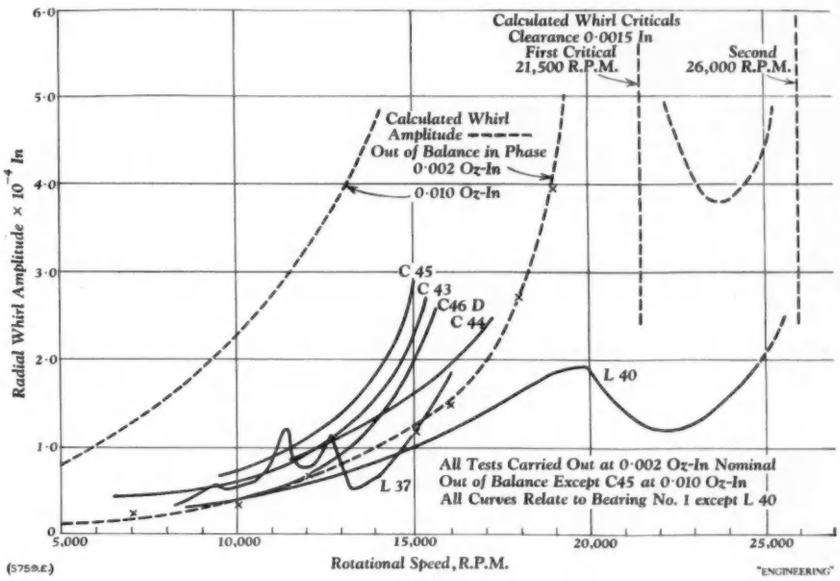


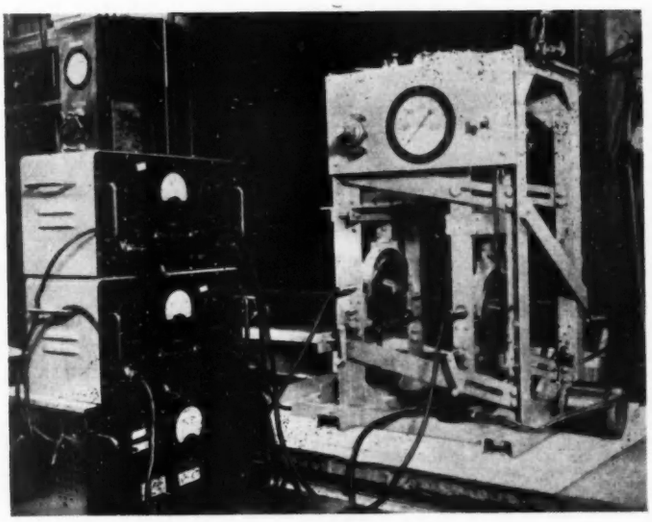
Fig. 5 The variation of whirl amplitude with shaft speed for shaft No. 2.

SIGNIFICANCE OF RESULTS

The full line curves shown in Figs. 3, 4 and 5 represent the measured amplitudes of whirl of the shafts (two were used, details are given in the table).

Bearing in mind that the shaft does not flex, that is, the machine is designed to run well below first critical flexure speed, we can form the relatively simple analogy by considering a shaft such as that shown in Fig. 8. This uniform shaft, of mass W lb, is supported by two hydrodynamic gas film bearings. Both theory and experiment reveal that the stiffness of such bearings (the increment in load component per

Fig. 6 Balancing machine with pressurised air bearing.



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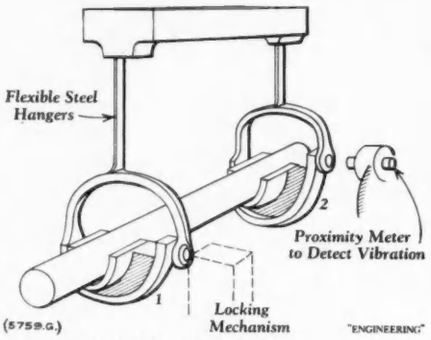


Fig. 7 Principle of balancing machine. Bearing 1 is locked while unbalance is detected at bearing 2.

increment eccentricity or displacement) is sensibly linear over a wide range of practical conditions. (Appendix II.) Ignoring gravity load and damping, and assuming the stiffness reaction of the film to be in line with the whirl or displacement at any instant, it is clear that we have a straightforward vibration system in which the critical speed is given by:

$$w^2 = \frac{2\,Kg}{W} \quad . \quad . \quad . \quad (1)$$

where K is the stiffness in, say, lb per in. In Appendix II it is shown that K can be expressed as

$$K = \alpha N \quad . \quad . \quad . \quad (2)$$

where N is the speed in r.p.m., and α is determined experimentally by load-deflection tests.

If we call the resonant or critical speed N_c, by combining (1) and (2) and

putting $$W = \frac{2\pi N}{60}$$

we get: $$N_c = 7{\cdot}05 \times 10^4 \frac{\alpha}{W} \quad . \quad . \quad (3)$$

Now if we give α a value of 7·8 lb per in per r.p.m., as found from experiments with bearings such as those used here, and if we assign a value of 26·7 lb to W, we arrive at a resonant speed of 20,600 r.p.m. This is reasonably close to that observed, bearing in mind the gross simplifications. Furthermore, it is higher than that observed in the experiments, a feature consistent with the inherent symmetry of the simple case discussed.

It appears that the whirl is excited by the disturbing force due to residual unbalance in the shaft, two cases of which are illustrated in Fig. 9. The force is considered to act through the mid-plane of each bearing.

Taking the simpler case of the two, in-phase unbalance, and expressing the unbalance as a distance between the geometric centre of the shaft (where the centre of gravity should be when perfectly in balance) and the displaced centre of gravity $dx = 2Z/W$, it can be shown[4] that the centre of gravity flies out at speeds below the critical, so that it is a total distance of $z + x$ from the central axis of the bearings. We then have:

$$W(z + x)w^2 - 2Kgz = 0 \quad . \quad (4)$$

which gives us an equation for amplitude;

$$z = \frac{2\,Z}{W} \frac{1}{\frac{2\,Kg}{Ww^2} - 1}$$

and making the substitution for stiffness (2);

$$z = \frac{2\,Z}{W} \frac{1}{\frac{N_c}{N} - 1} \quad . \quad . \quad (5)$$

where N is any arbitrary rotational speed,
N_c is the critical, or resonant, speed $= 7{\cdot}05 \times 10^4\,\alpha/W$
Z is unbalance in lb-in, equal and in phase at each bearing
W is the shaft mass, lb.

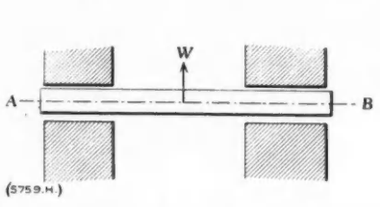
If z, the whirl amplitude, is plotted against the speed, N, it will be found that the resulting curve showing increase of amplitude with speed is very similar in shape to those found by experiment.

In Appendix I the more general case of a shaft with non-uniformly distributed masses is worked out. In this case conical modes of whirl are manifest, and the gyroscopic couple due to precession is included as an additional moment acting in the radial plane of whirl of the shaft.

Figs. 3 and 4 show results of these calculations as compared with the experimental results. Two shafts were used, one being lighter in mass than the other, and possessing a smaller transverse moment of inertia. Details of the shafts are given in the table.

Calculation confirmed the experiments inasmuch as the values of m, the apex distance of the cone of whirl, was such as to reveal the apex to lie between the bearings, hence giving rise to the phase difference of 180° observed at the two bearings.

When we consider the actual accuracy of the unbalance figures and the powerful effect of the clearance on the stiffness, it is understandable that greater concordance between the calculated and the experimental results might be hard to achieve. It is clear, however, that the order of magnitude is correct, and the general pattern is in qualitative agreement. In general, the whirl observed did not appear to be as bad as that anticipated by calculation. This may be because of the non-linearity of the film stiffness at large degrees of whirl. It might, on the other hand, be ascribed to damping. Only further experiment will reveal the reasons for this.



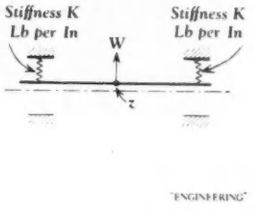
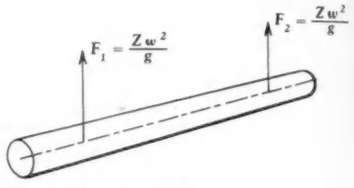
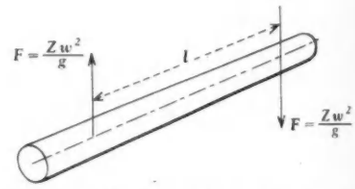


Fig. 8 Simple shaft system in two bearings.

Fig. 9 Residual unbalance of shaft.



(a) In Phase Out of Balance



(b) Out of Phase Out of Balance, Pure Couple

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Fig. 10 (a) Shaft with centre of gravity not midway between bearings. (b) Conical whirl about point 0.

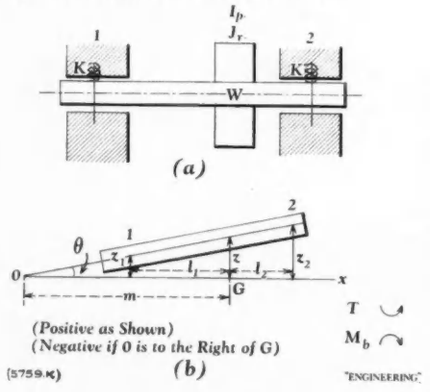


Fig. 11 Gearbox shaft carrying overhung impeller (oil lubricated plain bearings).

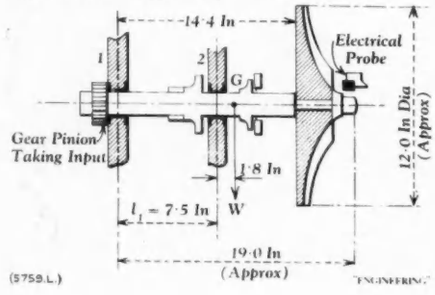
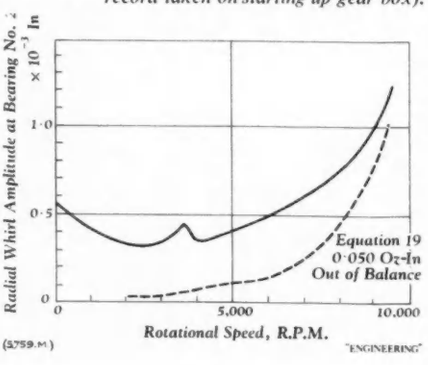


Fig. 12 Synchronous whirl of overhung gearbox shaft. (Moving film record taken on starting up gear box).



Avoiding Synchronous Whirl

Critical speeds evaluated from (8) (Appendix I) have been determined for a series of imaginary shafts carrying masses at various positions and with various distances between bearings (Fig. 15).

Bearings should be spaced as far as possible in cases where the conical mode gives the lower of the two critical speeds. Overhung masses should be avoided. Where nothing further can be done in a design, the best way to raise the lowest critical is to increase film stiffness by reducing clearance, a very powerful variable.

Application to Oil Film Bearings

There is no *à priori* reason why the treatment described might not be extended to high-speed machinery with plain oil-film bearings, provided that the shaft system is designed to run well below the first critical in flexure. An attempt was made along these lines to analyse the case of a high-speed blower which made considerable noise at the drive gears because of the high degree of whirl evinced by the shaft. This was ascertained by means of electrical probes.

Additional information from a mirror positioned along the length of the shaft provided evidence that it did not flex while running. Fig. 11 is a sketch of the shaft. Fig. 12 shows a record taken of the shaft whirl and shows that at its operative speed, 9,000 r.p.m., the amplitude was not far off a critical speed.

The broken line represents the result of a calculation carried out in the same way as with the gas film bearings. Unfortunately, there is much more uncertainty here, because it is not yet possible to measure the thickness of oil films very accurately, and therefore to estimate the stiffness of the film.

The bearings were 2·0 in diameter white-metalled bushes of 0·80 in axial length. The mean clearance was 0·003 in (cold). A value of stiffness constant α ($K = \alpha N$) of 21 lb-in per r.p.m. was calculated from an expression derived from Sommerfeld theory (Appendix II)

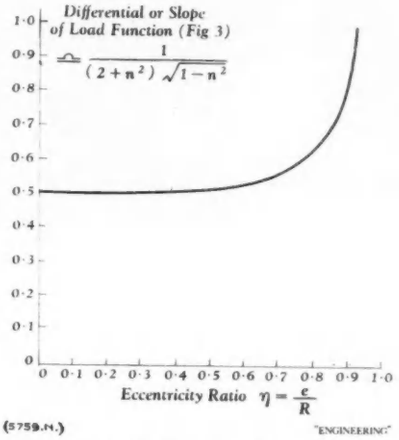


Fig. 13 Stiffness of theoretical bearings in the direction of the load.

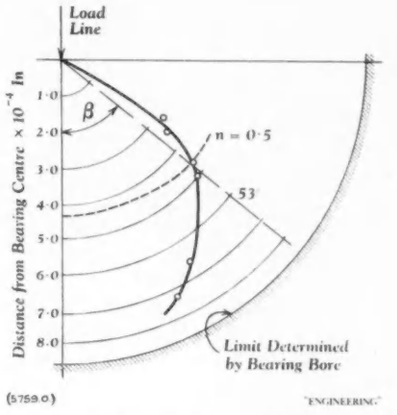


Fig. 14 Locus of observed shaft positions in 6 in by 4 in bearing.

applying both a length/diameter factor (0·23) and an arc factor (0·190).

The analysis revealed a lower critical speed of 10,400 r.p.m. and an apex of conical whirl close to the left-hand bearing. The latter condition was similar to that observed.

It is suggested that the approach described in this article be applied to a number of high-speed shafts in plain bearings so that some more data might come to hand. In any case it should be useful when considering such problems, as it might suggest straightforward cures.

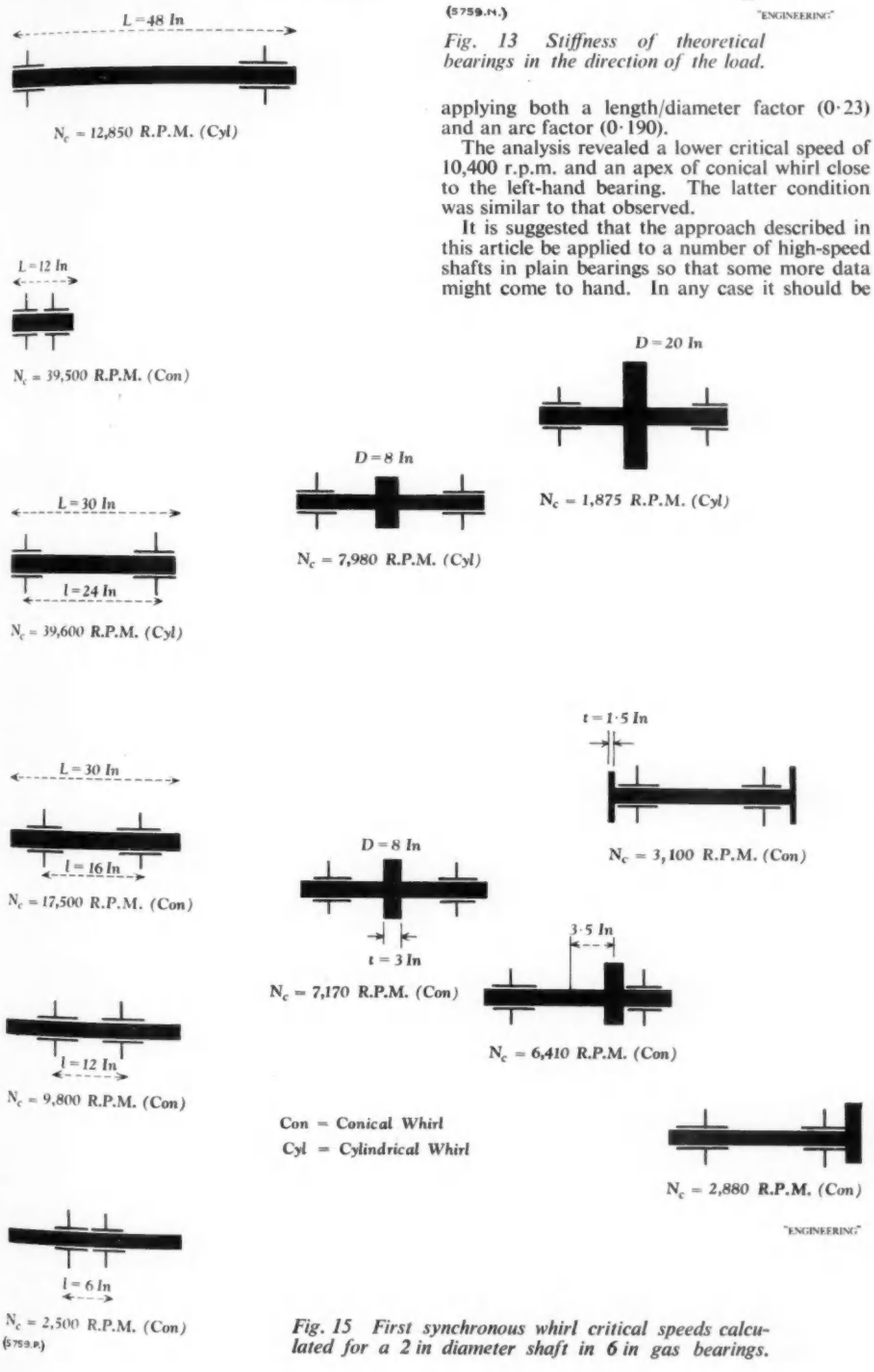

L = 48 In
N_c = 12,850 R.P.M. (Cyl)
L = 12 In
N_c = 39,500 R.P.M. (Con)
D = 20 In
D = 8 In
N_c = 1,875 R.P.M. (Cyl)
N_c = 7,980 R.P.M. (Cyl)
L = 30 In
l = 24 In
N_c = 39,600 R.P.M. (Cyl)
t = 1·5 In
L = 30 In
l = 16 In
N_c = 17,500 R.P.M. (Con)
D = 8 In
N_c = 3,100 R.P.M. (Con)
t = 3 In
3·5 In
N_c = 7,170 R.P.M. (Con)
l = 12 In
N_c = 9,800 R.P.M. (Con)
N_c = 6,410 R.P.M. (Con)
Con = Conical Whirl
Cyl = Cylindrical Whirl
N_c = 2,880 R.P.M. (Con)
"ENGINEERING"
l = 6 In
N_c = 2,500 R.P.M. (Con)
(5759.P.)

Fig. 15 First synchronous whirl critical speeds calculated for a 2 in diameter shaft in 6 in gas bearings.

GAS BEARING APPLICATIONS

Gas bearings should be seriously considered for the smaller sizes of gas turbine which are being developed by many organisations in various parts of the globe. According to the literature, the degree of dynamic balancing necessary to attain for small turbine shafts, so that they will run for a reasonable time in rolling type bearings, is extremely high, that is, of the same order as that employed for the gas film bearings under discussion here. In this article we have endeavoured to show that such perfection in dynamic balance, or, indeed, in manufacture as a whole, may not really be necessary when gas film bearings are used if some of the points mentioned here are observed at the outset.

Gas film bearings should be considered when projecting high speed pumps, turbines, etc., from the point of view of their adaptability to high temperature working.

As gas film bearings have no load carrying film at starting, it is essential to employ non-galling materials in bush and shaft. There appear to be many promising materials on the market already. (Polytetrafluoroethylene-bronze, graphite, etc.) The employment of a non-porous brand of graphite as a lining shrunk into a steel bush might show great promise, for the load carrying capacity of such material under dry starting conditions exceeds the load film capacity of gas bearings by an order of magnitude.

Mention is frequently made in the literature, both here and abroad, of the possibilities of nuclear power plant incorporating a helium cooled reactor in circuit with a closed cycle helium gas turbine. The major difficulties appear to lie in the direction of the problem of sealing. It is possible to visualise a totally enclosed turbine-alternator, however, supported entirely on gas bearings. There would be no sealing problem in such a case. Moreover, there should be no reason to dismantle the machine once it is made, since gas bearings are, to all intents and purposes, everlasting.

Acknowledgements

The author is grateful to the managing director of the United Kingdom Atomic Energy Authority (Industrial Group) for permission to make use of experimental results obtained while in the employment of the Authority.

APPENDIX I

Calculation of Whirl Amplitude

Expressions for critical synchronous whirling speeds and for amplitudes of whirl are derived by regarding the centre-line of the shaft as always lying within a plane which rotates about the

Continuing Research and Development

Details of shafts on which Whirl Measurements were Made

Item	Symbol	Shaft 1	Shaft 2
Total weight of shaft plus rotor, etc.	W lb	26·7	21·6
Distance, bearing 1 to c. of g.	l_1 in	5·60	5·83
Distance, c. of g. to No. 2 bearing	l_2 in	6·55	6·32
Polar moment of inertia about spin axis	I_p lb-in²	40·3	41·9
Transverse moment of inertia about c. of g.	I_t lb-in²	1,270	948
Experimental film stiffness of bearings with 0·0015 in clearance (Appendix II)	α lb per in per r.p.m.	7·82	7·82
Effective radii of gyration	k^2 in²	47·6	43·8
	r^2 in²	1·51	1·93
	q^2 in²	46·0	41·9
Difference of r. of g.	Δ in	+0·95	+0·49
Shift of c. of g. from mid position, l_2-l_1 =	y in²	74·3	74·1
Length constant, $l_1^2+l_2^2$			
Calculated distance from apex of cone of whirl to c. of g.	m in	−4·23	−1·69
Hypothetical whirl speed calculated from (3)	N_c r.p.m.	20,300	25,100
Lower calculated critical (from equation 8)	N_{s_1} r.p.m.	15,600	21,500
Second critical	N_{s_2} r.p.m.	21,000	26,000
Radial whirl amplitude at bearing 1 for 0·002 oz.-in in phase unbalance at 10,000 r.p.m. (equ. 10)	z_1 in × 10^{-4}	0·390	0·449
Radial whirl amplitude as above but anti-phase unbalance	z_1 in × 10^{-4}	0·313	0·102
Ratio of whirl amplitude bearing 1/bearing 2	z_1/z_2	−4·23	−1·62

bearing centre line at the speed of whirl or precession. In this way the problem is reduced to two dimensions only, and can be based on two equations, one for forces, the other for moments. For an exciting force consisting of equal in-phase unbalance of Z lb-in at each bearing position (Fig. 9a) we have;

$$\left.\begin{aligned} &W z w^2 - 2K g\left(1+\frac{\Delta}{2m}\right) + 2Z \;^{2} = 0 \\ &W(m^2+q^2) z w^2 \\ &\quad - 2K g z\left(m^2 + m\Delta + \frac{y}{2}\right) \\ &\qquad + 2Z m^2 w^2 = 0 \end{aligned}\right\} \quad (6)$$

where (Fig. 10) z is the radius of whirl at G (c. of g. of shaft) m is the apex distance of the cone of whirl to the left of G.

$\Delta = l_2 - l_1$

W is the mass of the shaft, etc.

$y = l_1^2 + l_2^2$

$q^2 = k^2 - r^2$, k being the radius of gyration of the shaft system about a transverse axis through G, and r the polar radius of gyration. A similar pair of equations applies to the case of anti-phase unbalance, Z lb-in, acting in opposite directions: (Fig. 9b)

$$\left.\begin{aligned} &W z w^2 - 2K g z\left(1+\frac{\Delta}{2m}\right) = 0 \\ &W(m^2+q^2) z w^2 \\ &\quad - 2K g\left(m^2 + m\Delta + \frac{y}{2}\right) \\ &\qquad + 2Z L m w^2 = 0 \end{aligned}\right\} \quad (7)$$

where L is the span between the bearings, $= l_1 + l_2$

Solving these equations so as to be compatible for all values of w, we obtain two critical speeds, which can be expressed thus;

$$p = \frac{N_{s1}}{N_c}, \text{ or } \frac{N_{s2}}{N_c}$$

(refer to (3) in text, N_c has the significance of a critical speed of cylindrical whirl with a symmetrical or uniform shaft of mass W)

$$p = \tfrac{1}{2}\left\{1+\frac{y}{2q^2} \pm \sqrt{\left(1+\frac{y}{2q^2}\right)^2 - \frac{2y-\Delta^2}{q^2}}\right\} \quad (8)$$

The radial amplitudes of whirl are given by:

$$\left.\begin{aligned} z &= \frac{2Z}{W}\,\frac{1}{\frac{N_s}{N}-1} && \text{(in-phase unbalance)} \\ z &= \frac{2ZL}{W}\,\frac{m}{2(q^2+m^2)}\,\frac{1}{\frac{N_s}{N}-1} && \text{(anti-phase unbalance)} \end{aligned}\right\} \quad (9)$$

where m can be evaluated from the quadratic:

$$m = \tfrac{1}{2}(\lambda \pm \sqrt{\lambda^2+4q^2}) \text{ where } \lambda = \frac{2q^2-y}{\Delta}.$$

Whirl amplitudes within the bearings 1 and 2 respectively are:

$$\left.\begin{aligned} z_1 &= \left(1-\frac{l_1}{m}\right) \text{times } z \text{ in equ. 9.} \\ z_2 &= \left(1+\frac{l_2}{m}\right) \text{times } z \text{ in equ. 9.} \end{aligned}\right\} \quad (10)$$

APPENDIX II

Note on Stiffness of Gas Bearings

Over a wide range of rotational speeds hydrodynamic gas bearings conform approximately to the Reynolds-Sommerfield laws. The theoretical load capacity is derived as:

$$P = 12\pi^2 L D \eta N\left(\frac{D}{C}\right)^2 \frac{n}{(2+n^2)\sqrt{1-n^2}}$$

where L is the axial bearing length,
D is the diameter,
η is gas viscosity in consistent units,
n is the relative eccentricity—c/radial clearance,
C is the diametral clearance.

Experiment shows that the film reaction P does not act in the direction of eccentricity, e, but at some angle β. Fig. 14 shows results of such measurements, a mean value of $\beta = 60°$ having been adopted as a reasonable value over the ranges of n up to 0·5, where the stiffness:

$$K = \frac{dP\cos\beta}{de} = 12\pi^2 \eta L\left\{\frac{D}{C}\right\}^3 N \text{ (function of } n)$$

is linear (see Fig. 15).

Within this range, we can put $K = \alpha N$ (equation 2), where α is determined from experimental data.

When rotational speed is increased indefinitely, or clearance decreased, we approach the compressible flow conditions described by Ford. In this case, angle β tends to zero, the gas film stiffness becomes constant and the whole problem becomes similar to those dealt with by Timoshenko[2]. When angle β tends to 90°, that is, loading is relatively light combined with relatively high speeds, the shaft tends to run into the "half speed whirl" condition mentioned by Hagg[3] and Cameron.[5] This is a very dangerous condition for the bearings which, so far, has not been sufficiently studied to enable useful generalisations to be made.

REFERENCES

[1] Ford, G. W. K., Harris, D. M., and Pantall, D., "Principles and Applications of Hydrodynamic Type Gas Bearings," *Proc.I.Mech.E.*, 1957, vol. 171 No. 2, p. 93.

[2] Timoshenko, S. (1951), *Vibration Problems in Engineering*, 2nd Ed., New York. Van Nostrand Co., Inc.

[3] Hagg, A. C., "Some Vibration Aspects of Lubrication," *Lubrication Engineering*, August, 1948.

[4] Woodrow, J., UKAEA Report, AFRE E/R 663 (1951), "Critical Speeds of Rotor in Gas Journal Bearings."

[5] Cameron, A. "Oil whirl in Bearings" ENGINEERING 1955, vol. 179 p.237

NRDC REDEFINED

The position and purpose of a publicly financed organisation in the field of industrial research were redefined in the annual report of the National Research Development Corporation. No research on defence problems is involved: all relates to new products or processes which have commercial applications. In their report, the Corporation's chairman, Sir William Black, and their managing director, Lord Halsbury, discuss the scope which exists for their activities. They discount both the extreme views which are sometimes put forward. One asserts that the management of industry is so close to perfection that industrial neglect of some possible line of development is conclusive proof of its impracticability. The other asserts that the management of industry is so neglectful of opportunities for development that the economic survival of the nation is imperilled.

Clearly both arguments are false. The nation's productivity has been advancing significantly since the war. On the other hand, Lord Halsbury and Sir William say "we find it difficult to believe that in the selection of targets for development, as indeed in any other branch of human effort, perfect efficiency is ever attained or is even attainable. Just as a smoothly flowing river will in general carry a burden of timber to the sea, so the main burden of industrial development is carried by the broad stream of industrial initiative towards its consummation. And just as some bend or sunken rock may cause a log jam which requires to be loosened up so that the process may go forward, so some adverse combination of circumstances may hinder a desirable development from proceeding smoothly until external intervention prises loose the obstruction and gets the normal process once more under way."

If proof were required that NRDC's activities are useful and beneficial, it is provided by their profitability. As Sir William Black points out "at the head of any list of successful projects we would surely place the inventions while licencing to industry is bringing in a growing revenue which amounted to £174,242 in the year under review." The goods made under licence from the Corporation must now amount to an annual total of many millions of pounds. The work now being sponsored or carried out on electronic computers, computer-controlled machine tools, oil-drilling rigs, agricultural machinery, and so on, should yield substantial additional income and fully warrants the Government's decision to extend even further the Corporation's life and powers.

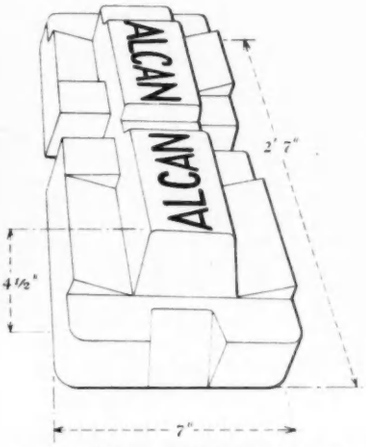
FERRITE CORES FOR NEUTRON DATA

A transistorised data recording and analysing system for neutron spectrometry has been developed by EMI Electronics Limited, Hayes, Middlesex, in conjunction with the UKAEA. The system is made up of a number of self-contained recording units and a central high-speed analyser. Neutron time of flight and scintillation counter identity are converted by recording units near the experiment to binary coded digital form. The coded data, at a typical resolution of 0·2 per cent are then recorded on magnetic tape in parallel form on 16-channel 1 in tape.

At the end of the recording run, which may be for up to 24 hours, the tapes are removed for processing on the central analyser. At speeds of up to 100 in per second, the digital information is read off the tape and sorted into a ferrite core store. The information is then in a suitable form to be read out at speed into any further data processing equipment that is to be used. For example, the core contents can be transferred on to punched paper tape for direct input to a digital computer; alternatively, punched card or graphical output from the core store can be provided.

Metals and Materials

INTERLOCKING ALUMINIUM INGOTS



Of the 160,000 lb of primary aluminium distributed in this country last year by Aluminium Union, nearly three-quarters was in the form of 50 lb ingots. Now the producers—Alcan, who have Canadian smelters in Kitimat and Arvida—have developed a new interlocking design for this ingot which it is claimed makes handling safer, easier and faster, and will enable better use to be made of shipping and storage space and of mechanical handling equipment. The new design ensures that in strapped bundles the ingots are locked together in three dimensions, and the good stability of such bundles is shown in the illustration. Limited quantities are currently available in this country in the 99·5 per cent purity, through Aluminium Union Limited, The Adelphi, London, W.C.2.

Bundles of the new 50 lb ingots have improved stability.

EXTRACTS OF WOOD

In 1957 the world wood harvest was lower than in the previous year but new records were set up in production of plywood, chemical woodpulp, newsprint, paper board and fibreboard. The volume of forest products exported increased by 4 per cent while the value of exports was up by about 3 per cent. But according to the recently published FAO *Yearbook of Forest Products Statistics* the world output of sawn wood, the main wood commodity, was down by only 4 per cent in spite of a fall of 12 per cent in North American production. About 90 per cent of the world sawn wood exports in 1957 were of coniferous species and of these 82 per cent were shipped from Europe and North America. In the present decade Europe has changed from being a net exporter of coniferous sawnwood to a net importer. Meanwhile the USSR has become a net exporter. The United Kingdom and the United States continue to be the main importers of sawn wood.

World production of plywood increased by 4 per cent in 1956 the leading producers being the United States, USSR and Japan. The United States although a major producer, imported 40 per cent of total world plywood imports, while the United Kingdom took 31 per cent. The North American countries produced 58 per cent of the world's total woodpulp output. Finland, Norway and Sweden produce a further 17 per cent. The production of newsprint has gone up every year in the past decade. The 1957 figure of 12·35 million tons was the highest yet. Canada, the leading producer, accounted for 47 per cent of the world total. The all-time record paperboard production of 20·4 million tons was achieved in 1957. Well over half of this came from North American mills but Japan, China, West Germany, Finland and the Netherlands showed increases. Fibreboard, the newest of the family of pulp products went up slightly to reach a world output of 3·4 million tons.

All told the quantity of pulp products of all kinds exported increased from 10·8 million tons to 11·1 million tons. Those from Europe went up by 6½ per cent and those from N. America by 1 per cent. Canada exported three quarters of total world newsprint shipments. Britain and the United States continue to be the biggest importers of pulp products.

SAND SEAL FOR CASTING EPOXIDES

With the wide use in foundries of the CO_2 process for making sand moulds, coupled with the now rapidly growing use of epoxide resin patterns and core-boxes, it would seem logical to use CO_2 sand moulds for casting epoxide patterns, in place of the currently used plaster moulds. The fact that the process has not so far been used on a commercial scale for casting epoxide resins is due to the difficulty of providing an effective seal to prevent penetration of the resin into the mould, which becomes more severe as the grain size of the mould material is increased. However, recent work by Leicester, Lovell and Company Limited, North Baddesley, Southampton, has provided an answer to this problem in the form of Epophen Mould Seal. The compound is described as a vinyl polymer in a volatile solvent, and although it is satisfactory with most grades of sand normally used for CO_2 moulding, the surface finish of the cast resin is still dependent on the grain size of the sand used. A feature of epoxide resins is their low shrinkage on casting and curing—of the order of 0·0002 to 0·0004 in per in, which for many applications eliminates subsequent machining operations, and use of a fine sand may therefore, as with plaster moulding, sometimes obviate the need for any finishing treatment.

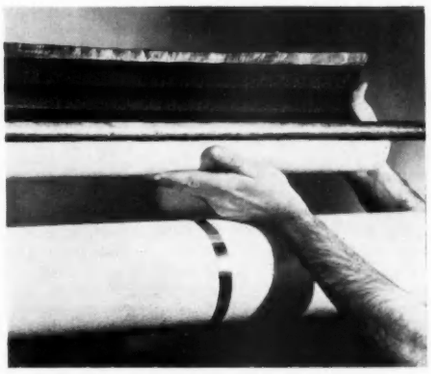
MAGNETIC ALLOY OF PLATINUM

The magnetic properties of certain alloys in the cobalt-platinum system have been known to metallurgists for many years, but it is only in recent times that the properties of the alloy containing an equal number of atoms of each element (23·3 per cent by weight of cobalt) have been fully appreciated. Platinax II, produced by Johnson Matthey and Company Limited, is the latest development in this field and is one of the most powerful permanent magnet materials. After heat treatment a remanence of about 6,400 gauss, a coercive force of 4,800 oersteds and a BH(max) of $9{\cdot}2 \times 10^6$ gauss-oersteds may be achieved. In the heat-treated state the alloy is magnetically isotropic, exhibiting similar magnetic properties in all planes.

Apart from the benefit of its magnetic properties, Platinax II offers a further advantage in that the alloy is comparatively workable before heat treatment and can be machined, rolled and drawn without difficulty, so lending itself to the manufacture of magnets of complicated shape or extremely small size.

Further information on Platinax II—including cost—is available on application to the company's head office at 73-83 Hatton Garden, London, E.C.1.

FOAMED GLASS INSULATION



Pittsburgh Corning Corporation, Pittsburgh 22, Pa., USA, are producing rigid insulation for protection of piping at temperatures up to 350° F from foamed glass.

The covering is made in thicknesses of 1 and 1½ in to fit around a pipe of ½ to 6 in dia., and is supplied in 24 in lengths. The main feature of the new product, called Stay-Dry, is the ease and speed with which the covering may be applied, but it is also claimed that the material is vapour proof, incombustible, waterproof, and has sufficient strength to enable most normal hanger fitments to be placed outside the insulation.

Cellular glass provides good insulation and is easy to instal.

Book Reviews

LANGUAGE TRANSLATION BY COMPUTERS

Mechanical Resolution of Linguistic Problems. By ANDREW D. BOOTH, L. BRANDWOOD and J. P. CLEAVE. *Academic Press Incorporated, 111 Fifth Avenue, New York 3, N.Y., USA.* ($9·80); and *Butterworths Scientific Publications, 4 and 5 Bell Yard, London, W.C.2.* (50*s*)

It is an old question whether the translation of languages can be made mechanical. The appearance of electronic computers and the suggestion that these might be programmed for translation have given new life to the subject. The method adopted is basically simple. The original text is read, words identified and translated by a dictionary, necessary changes of word order made and the translated text produced as output. However, this picture of mechanical translation (MT) is too naive; actual languages are not so simple but bristle with difficulties like inflections, irregular verbs and idioms. The actual technique of searching is not easy, for a dictionary containing all possible forms would be enormous, and when the dictionary is consulted—the machine does this with every word—an economic look-up procedure is essential. It is then necessary to examine syntax and context to produce an intelligible rendering. Two methods have been suggested for this: the first stores all the relevant information with the dictionary entry, the second has a dictionary of contexts (like Roget's Thesaurus). Even so, for many years to come the use of MT will be confined to scientific abstracts and papers. For the past ten years much effort has been directed towards MT. Very little of the work done so far is readily accessible and Dr. Booth and his collaborators have set out to give an account of their results. Unfortunately their book is a disappointment.

A (selective) survey of work in MT between 1947 and 1956 is followed by an account of computers. The first suggested application to language analysis, not strictly MT, is word counting and making a concordance. The analysis of style follows, particularly as applied to Platonic chronology. There is one further chapter, not directly concerned with MT, on transcription of Braille. MT is discussed in two general chapters, on dictionary searching, the "stem-ending" method of analysis, identification of idioms and a possible method for resolving multi-meanings. These ideas are applied to French and German.

The authors claim to have translated French successfully on the APEXC at Birkbeck College but give no actual examples. The scheme was limited because the computer could only hold a dictionary of 250 words. The translation programme is not given, either in outline or in detail, neither is the dictionary. The analysis of German (162 pages) dominates the book and demands an extremely good knowledge of grammar. The chapter has a scheme for translation, which has not, apparently, been attempted on a computer. Examples are given of the many difficulties but the non-linguist is not helped by the fact that the critical words are not always pointed out. There is also a detailed examination of a sample text of 7,000 words (on electron optics); again there are no translations and no hint of how the suggested machine procedure would work for even this selected text. The book finishes with a short account of some Russian work on MT, a brief discussion of multilingual translation and proposals for a specialised computer for MT.

The distinction is never clearly made between actual achievements and untried suggestions. In a book of this length, claiming partial success, it is surprising not to see a single *phrase* where the authors can say: "Here is the machine's translation."

There are several signs of carelessness: there are two conflicting definitions of the "collate" order on a computer (p. 15 and p. 87), neither of which corresponds to usual practice; the example of the branch instruction (on p. 31) and the count of noun-blocks on p. 162 are wrong; there are others, and also some misprints. We must still await a book on MT that tells us just how it is done and what we may expect from the machine.

Paul. A. SAMET

NEW BOOKS

Problems in Engineering Structures. By R. J. ASHBY and A. H. CHILVER. *Edward Arnold Limited, 41 Maddox Street, London, W.1.* (16*s*)

The purpose of the book is to give the first and second year University student of engineering structures an additional aid in the form of worked examples, in which sufficient explanatory matter is given to indicate the steps in the solution.

Design of Eccentrically-Loaded Columns by the Load-Factor Method. By J. D. BENNETT. (8*s*)

Tables for the Design of Beams and Slabs. By JACQUES S. COHEN. *Concrete Publications Limited, 14 Dartmouth Street, London, S.W.1.* (4*s*)

These brochures have been prepared to simplify the design of reinforced concrete in accordance with the load factor method as recommended for the first time in Great Britain, by British Standard Code No. 114 issued in 1957. Mr. Bennett's work gives 20 charts for the design of columns subjected to direct load and bending about one axis of symmetry and reinforced symmetrically or unsymmetrically with mild steel and cold-worked bars. Mr. Cohen's tables relate to the design of rectangular beams by the load-factor method and also by the elastic method. Worked examples are given with both sets of tables.

Univalent Functions and Conformal Mapping. By JAMES A. JENKINS. *Springer-Verlag, Reichpietschufer 20, Berlin, W.35, Germany.* (*DM* 34)

This monograph deals with the application of the method of the extremal theory of univalent functions.

Cores and Core-Making. By FRANCIS D. ROPER. *George Allen and Unwin Limited, Ruskin House, Museum Street, London, W.C.1.* (21*s*)

This book is a study of the basic principles of core-making practice and is concerned also with the finer points of the art of core-making. It has been written mainly for the craft apprentice and foundry student.

Circuit Analysis of Transmission Lines. By JOHN L. STEWART. *John Wiley and Sons Incorporated, 440 Fourth Avenue, New York 16, N.Y., USA.* (85·50); and *Chapman and Hall Limited, 37 Essex Street, London, W.C.2.* (44*s*)

Intended as a textbook for American undergraduate electrical engineering courses, the book provides a short unified treatment of the analysis of ordinary transmission lines. The more important graphical techniques are also discussed. Special attention is given to radio frequencies and measurements. Matching devices, the design of resonators, and transmission cavities are covered; the standing-wave ratio is discussed; and the principles and applications of the Smith chart are introduced.

Integral Equations. By F. SMITHIES. Cambridge tracts in mathematics and mathematical physics No. 49. *Cambridge University Press, Bentley House, 200 Euston Road, London, N.W.1.* (27*s* 6*d*)

The book is devoted entirely to non-singular linear integral equations, that is, those for which the main results of the Fredholm theory are valid. The contents include the resolvent kernel and Neumann series; the Redholm theorems; orthonormal systems of functions; the Fredholm formulae for L_2 kernels; Hermitian kernels; singular functions and singular values. A bibliography is included.

Anti-Corrosion Manual 1958. *Corrosion Prevention and Control, Scientific Surveys Limited, 97 Old Brompton Road, London, S.W.7.* (50*s*)

The first of an annual series, this volume contains information on all aspects of corrosion. The written style allows easy digestion of the contents, which although up to date in factual information contain sufficient background to be understood by those not versed in the subject. The outlook is essentially a practical one in realising that corrosion is not a theoretical science but a real menace. Rudiments of theory are backed up by tabulated properties of newly developed materials to yield a handbook which should enable those fighting the good fight both to know their enemy better, and to provide themselves with more effective defences.

Proceedings of the Tenth British Electrical Power Convention, 1958. *Lea and Company Limited, 15-19 Broad Street, Northampton.*

Of necessity a book to be read through rather than referred to since there is no index. Papers given are "The Development of Nuclear Energy for Electricity Supply in Great Britain"; "The Development of Nuclear Energy for Electricity Supply Overseas"; "Britain's Part in Electrical Development overseas"; "British Hydro-Electric Plant and World Power Requirements"; and "The Development of the Electrically Equipped Kitchen." A nice study in anti-climax.

ELECTRON BEAMS AND WAVES

Electronics of Microwave Valves. By W. J. KLEEN. *Academic Press Incorporated. 111 Fifth Avenue, New York 3, N.Y., USA.*

High-power radar at centimetre wavelengths became possible when the magnetron was found to be an ideal microwave pulsed oscillator. Magnetrons were designed and manufactured in large numbers when nobody really understood their electronic mechanism of operation. The stimulus that this lack of understanding gave to the study of electron motions in high frequency fields crystallised the ideas of synchronous interaction of electrons with the electric field component of rotating or travelling waves. The success of the travelling-wave tube, which uses this idea in its simplest form, established the fundamental theory of electron beam and "slow" wave interaction. Several micro-wave amplifiers and oscillators have evolved from this basic principle, using the special properties of various slow-wave propagating structures and different ways of focussing and confining the electron beam. At the same time improvements in understanding and technology have extended the useful frequency range of tubes of conventional construction.

In this book Dr. Kleen brings together the important information on the theory of microwave valves of the kind which depend for their action on the presence of an electron discharge. Each chapter deals with a separate topic and is complete in itself. The treatment is lucid, although of necessity somewhat compressed. There is an excellent bibliography for each chapter, or group of chapters, so that the book is an ideal introduction for the intending microwave specialist. It should also be a useful reference book for the practising tube engineer whenever he needs to think again about fundamentals.

Thanks are due to the publishers and translators for their foresight and competence in producing a nicely anglicised version of this book.

M. ESTERSON

PREPARING TO BE UNCONVENTIONAL

Mechanical Engineering Thermodynamics. By DAVID A. MOONEY. *Longmans, Green and Company Limited, 6 and 7 Clifford Street, London, W.1.* (45*s*)

The American edition of this work, which has been available in this country for some time, is already familiar to many recently graduated engineers. To them it requires no recommendation. It was one of the first, if not the first, student text available in this country which was acceptable to those teachers who had adopted the " Keenan " presentation of thermodynamics. Even today, the average course on thermodynamics or, as it is more commonly called, heat engines or applied heat, merely provides students with the various formulae required to analyse conventional work-producing and-absorbing devices. Regrettably, for examination purposes this treatment has proved sufficient, but it does not provide the fundamental background required to understand and analyse the new and the unconventional.

The teaching method evolved by Professor Keenan of the Massachusetts Institute of Technology differs in that it provides students first with the fundamental relationships between heat, work and the properties of systems, and then shows them how to use these relationships to analyse all the conventional devices. The formulae derived are, of course, the same as those provided by a heat engines course, but the student is more dependent on his reasoning powers than his memory, and more aware of the assumptions that have to be made before thermodynamic analysis can begin.

As Keenan's otherwise admirable text presents some initial difficulties to students the author, who taught at MIT before entering industry, has endeavoured to provide a more elementary interpretation. In this he has succeeded. His text covers the ground required for the first two years of a three year mechanical engineering degree course, and is thus also suitable for students of other engineering faculties who follow a common first-year course. As this emphasis on the fundamentals of thermodynamics spreads from the universities to technical colleges and elsewhere, so will this book appeal to a wider audience. It seems desirable that this change should be made rapidly because at present two types of engineer are being trained, who will find it difficult to communicate with each other, and thereby widen the unfortunate gulf that still exists between graduate and " practical " engineers.

Many teachers are, of course, bound by an externally imposed syllabus, and are not free to change. It is unfortunate in this respect that the Institution of Mechanical Engineers did not take advantage of the chance provided by the recent revision of their examination syllabuses to put their examinees on an equal footing with their graduate members. This book cannot, therefore, be recommended to students taking the conventional heat engines course, as it can only add to their confusion, but it is to be hoped that their teachers will at least examine a copy, if only to criticise.

To those who accept the general method of presentation, comment and criticism of the content can only concern those differences of opinion which always exist between teachers of any subject. Only two are worth mentioning. Firstly, Mooney's use of the term energy to include heat and work seems to be too general, and thus a potential source of confusion with internal energy. Secondly, his treatment of the Second Law corollaries, particularly the proof that entropy is a property, could be improved. The bulk of the subject matter, however, is presented clearly and logically and will be found very useful by those students for whom it is intended.

In due course there will undoubtedly be as many textbooks on thermodynamics as there are at present on heat engines. It is to be hoped that they will maintain the standard set by this example.

J. A. DALLENDER

The Reviewers

Dr. Paul A. Samet, who obtained his B.Sc. in mathematics at Manchester and carried out research in number theory at Cambridge for his Ph.D., is lecturer in the computing laboratory at the University of Durham. He previously served with the Royal Radar Establishment, Malvern, and the Royal Aircraft Establishment, Farnborough.

Mr. M. Esterson is deputy manager of the radar valve division in the English Electric Valve Company. He holds a B.Sc. in electrical engineering and is a graduate of the Institution of Electrical Engineers.

Mr. J. A. Dallender is at present a lecturer in power generation at the Royal School of Mines. He began his career as an apprentice with the Fairey Aviation Company, and after serving throughout the war with the Royal Artillery, entered City and Guilds College, London, where he obtained a B.Sc. in mechanical engineering. He is an associate member of the Institution of Mechanical Engineers.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given though distribution is sometimes restricted.

Construction

Site Inspection. SITE INVESTIGATIONS CO. LTD., The Green, Southall, Middlesex. The technical services provided by the firm for checking underground conditions at sites are described in a comprehensive brochure.

Steel Structures. DOMINION BRIDGE CO. LTD., PO Box 280, Montreal, Quebec, Canada. The booklet " Builders in Steel " provides a comprehensive account of the firm's activities and manufacturing facilities as well as of its special products.

Precast Concrete. CONCRETE LTD., 16 Northumberland Avenue, London, W.C.2. " Bison " precast reinforced planks, purlins, slabs and piles in standard size ranges. Illustrated brochures for each group.

Autopark. R. S. PEARCE & CO. LTD., 11-19 Cornwall Street, Birmingham 3. The Pearce Autopark system for multi-floor storage of cars. Semi-mechanical system using lifts and trolleys. Brochure.

Asbestos Sheeting. TURNERS ASBESTOS CEMENT CO. LTD., Trafford Park, Manchester 17. " Everite " lightweight corrugated asbestos cement sheets for general construction; standard flat sheets 21 in wide and up to 8 ft long. Various colours. Also ridge pieces, etc. Booklet.

Glass Fibre Insulation. VERSIL LTD., Rayner Mills, Liversedge, Yorks. Glass fibre insulation for all types of plant and building. Rigid sections for pipes, mattresses faced with wire netting, or ravelled fibres for loose filling. Brochure.

Chemical Vessels. METAL PROPELLERS LTD., 74 Purley Way, Croydon, Surrey. Brochure CP58 describes examples of reaction and mixing vessels made in stainless steels and other alloys for the oil and chemical industries. Also included are tables of stainless steels giving composition, etc.

Scaffolding. MILLS SCAFFOLD CO. LTD., Trussley Works, Hammersmith Grove, London, W.6. " Self-Lock " scaffolding system consists of frames that slot together. Standard size 5 ft by 2 ft weighs 24 lb. Folder gives details and examples.

On the Shelf

By Frank H. Smith

Those addicted to the correct presentation of technical information (Kappists for short) will be delighted, if they happen to be Mancunians, to hear of a course to be held at the Manchester College of Science and Technology on PTI (NOT physical training instructors). The eight lectures cost 30*s* and enrolment will take place during the half-hour preceding the first lecture on 17 February. Commander D. K. McCleery, the organising lecturer, has mustered an imposing array of associates in Professor Kapp, Mr. B. C. Brookes, Mr. G. Parr and Mr. L. L. Ardern, the College Librarian. Enrolment should not be confused with applications to attend, a form for which is obtainable from the College. In advising me of this course, Mr. Ardern quotes, as an example of fog-making, the letter in ENGINEERING of 9 January where reference is made to *ZAMM*. Hands up all those readers who know what those initials stand for? (Don't worry, *I* do.)*

Doing a bit of drawer-clearing in the New Year I came across a couple of items which I do not think I mentioned last year and which may interest you. The University of London Library, Senate House, Malet Street, London, W.C.1, whipped up a " Union List of Periodicals on Mathematics and Allied Subjects in London Libraries." There are 627 titles with the libraries in which they are lodged and, what is more, a list is provided of some of the abbreviations and alternative titles which are sometimes found in lists of references. The Goldsmith's Librarian at the University will provide further information. Its price is 5*s* post free. The other item is entitled " Library Services and Technical Information for the Radio and Electronics Engineer " at 2*s* 6*d* from the British Institution of Radio Engineers at 9 Bedford Square, London, W.C.1. This gives details of the BIRE Library and catalogue arrangement, the UDC as applied to subjects, a subject catalogue and author index, a list of periodicals taken, and other useful material.

Dover Publications, who seem to have moved to 180 Varick Street, New York 14, have produced " Guide to the Literature of Mathematics and Physics " at $2·49. This includes an up-to-date listing of agencies and individuals (presumably in the United States) engaged in translating from the Russian. Anyway, Constable should be able to supply details since they are agents in this country for Dover.

The Editorial of Butterworth's *Research Applied in Industry* for January is as surprising as it is interesting. Entitled " Sales Talk " it provides some interesting figures on expenditure on publicity in this country. They estimate that we spend £350 million per year. Incidentally, the journal refers to a conveyer belt. With a penultimate e. Can this be another " propellent "?

My Mrs. Mop was delighted to see, on page 33 of *Nature* (which incidentally has changed the format of its weekly index this year) a contribution entitled " Smoke emission of low-temperature chars." As she said " A hot number like me usually steams when I'm on me brasswork."

From the Mechanical Engineering Research Laboratory (MERL) of the DSIR, East Kilbride, Glasgow, somes news of their Research Summaries. These are " to help firms with engineering interests to keep in touch with results of recent research which are of direct industrial interest." There's the rest of a quarto sheet of this so drop a line to MERL if you are interested. Summaries already prepared are " Measuring the air content of oils "; " Strength of pin-joints "; " Measurement of large water flows "; " World literature on heat transfer "; and " Design of hydraulic relief valves."

* Zeitschrift für angewandte Mathematik und Mechanik.

Design

Loading position.

Firing position.

A NOVEL FLASHLESS AND RECOILLESS GUN

By Lt. Col. L. V. S. Blacker O.B.E., A.F.R.Ae.S.

The weapon shown in the illustrations above has been devised and developed to meet the very urgent need now experienced by infantry for defence against tanks, and for one without the serious disadvantages of present models. The gun is of the type which discharges a " counter-shot " to the rear, the recoil force of the counter-shot counteracting that of the forwardly discharged projectile.

As will be seen from the illustrations, the rear barrel is set at an upward angle to the axis of the forward barrel so that the rear muzzle is so high from the ground that a man may lie, or even kneel, behind it in complete safety. The consequence of setting the two barrels at an angle is to create a resultant force acting on a line which bisects the angle at the meeting point of their axes. This line meets the ground through a wooden base, which is in compression. The force which this has to sustain is, in practice, small.

The countershot, which is discharged rearward and upward, consists of small lead pellets (i.e. No. 8 bird shot) in a light metal canister. The latter breaks up a short distance in rear and a few score feet up. The pellets fall harmlessly to the ground, while the empty canister is allowed to fall gently under a small parachute similar to that now used with illuminating flares.

The weapon is breech-loading, and in order to achieve this, the front barrel is connected to the centre portion by an interrupted screw, as in BL ordnance, and when released is run forward along a pair of curved guide rails sufficiently to allow the complete round to be inserted into the chamber. This is at the rear of the forward barrel. The breech is then closed by a reverse motion.

The joint is sealed by an expanding ring. Electric firing contacts are provided which allow firing current to pass when the breech is locked. This current is provided by a magneto device actuated by a hand grip of the usual type. No traversing pivot is needed, and no elevating gear, because the entire piece is in balance and has therefore a free swinging traverse, from a shoulder piece, as with a small arm.

There are two forms of sight. The one is all metal, provided with means for setting the range and for compensating for enemy course and speed. The other is optical and, as in modern photographic gear, combines range-finding with setting for distance of object.

The weapon is a smooth bore. The projectiles, as will be seen from the illustration, are very carefully streamlined and not rotated, but stabilised by means of a drum-shaped tail. Much practical experiment has shown that such faired missiles may have roughly half the drag of ill-shaped ones, such as those employed with rifled weapons and which have projecting driving bands and nearly flat bases.

In consequence of this, for a given muzzle energy, the trajectory may be only half as high as with the ill-shaped rifled projecile. Conversely, to achieve an equally flat trajectory and gentle angle of descent, this projectile needs to have imparted to it only two-thirds the initial velocity and therefore only half the muzzle energy. This in turn has enabled the designer to halve the weight of the weapon.

The flatness of the angle of descent is of the utmost importance to the infantryman when engaging a vertical target, because in the heat of battle he has, unlike the artillery man, the greatest difficulty in estimating the range. Therefore his effective fighting range will be proportionate to the flatness of this angle of descent. An additional advantage is that, off average ground, a well-shaped projectile will ricochet with effective results. Yet again, an unrotated projectile does not spoil the perforative performance of a shaped charge warhead. Although " squash-head " projectiles may be provided, especially for use against brick and concrete, the best warhead against armour is the shaped charge type, which from this model can perforate the armour of the heaviest tanks in existence.

Furthermore, because of the efficient flight of the aerodynamically correct projectile, the propellent charge needed is remarkably small so that there is no smoke, blast or perceptible flash. By reason of this the soldier may expect to load and fire more than a dozen shots at an advancing tank while it runs up to him. This favours the shaped charge, as against the " squash-head." The weapon has proved itself extremely accurate, largely because efficient gas checks are provided for both forward and rear projectiles, while the same propellent charge propels both. Means are provided for adequate early confinement of this charge. An experimental rocket-assisted projectile has been made and is undergoing trials.

The new weapon weighs only 90 lb as against the 1,600 lb of existing weapons of no greater performance. This includes an operational or fighting range as great as atmospheric conditions of visibility will allow. In other words, these weapons depend on direct fire against targets which must be picked up by the human eye.

The equipment divides up into three quickly detachable man-pack sections of 30 lb each. It is therefore a genuine infantry weapon, not cumbered by wheels. Manufacture is remarkably simple. There is no high precision machining or honing except in the sights, nor are special materials or alloys needed.

The gun, designed for infantry defence against tanks, employs a counter-shot to balance recoil. The projectile is streamlined and is stabilised by a drum tail.

SUPERSONIC DESIGN STUDIES

Co-operative Wind Tunnel

A new supersonic wind tunnel for speeds ranging from Mach 1·4 to 3·5 has recently started work at the Aircraft Research Association, Bedford. ARA, it may be recalled, is a co-operative research association for the aircraft industry, which went into operation in May, 1956, when HRH the Duke of Edinburgh opened the Mach 0·6-1·3 transonic tunnel (ENGNG., vol. 181, 1956, p. 312). To the 14 firms then supporting the venture has now been added Airco—the de Havilland-Fairey-Hunting consortium, which is to build the DH121 airliner for British European Airways. The wind tunnel work of ARA, at first largely concerned with military projects, is becoming increasingly directed towards the civil field; one of their undertakings is the investigation of a variety of shapes for supersonic airliners with the object of determining the most economic configuration.

TRANSONIC PROGRESS

Before describing in detail the design of the new supersonic tunnel, it may be of interest to summarise progress in the transonic tunnel, which started model testing for the industry in February, 1957. In December, 1957, a fatigue failure of the blades of the axial compressor occurred, due to an unsuspected resonant condition, and tunnel running was limited until repairs were completed in June, 1958. Some 35 tests on 18 different models have now been completed, and the total fan running hours are over 1,300. The tests made have included normal force measurements on both complete and partial models of aircraft and missiles, and more extensive pressure measurements on jet intakes and on a propeller turbine intake with a cropped propeller being driven by a hydraulic oil motor inside the model. Much use has been made of techniques which make the flow lines over the surface of models visible by using oil. A closed circuit television is used to observe these details on the model. Development of methods for testing flutter models is under way, together with the installation of sufficient air storage at high pressure to enable jet efflux effects to be reproduced on models.

A small 8 in by 9 in transonic tunnel of the "blow-down" type has been built to provide a means of doing small scale pilot experiments on any rigs which might be required in the large tunnel. It uses an injector drive from a compressed air supply and will run for up to 2 minutes. It covers a Mach number range from subsonic to Mach 1·3. A simple flexible nozzle is provided, adjusted in this case by one screw jack, and the working section itself can either be fitted with two perforated walls with two glass windows on the other walls or with four perforated walls.

A new Zebra computer made by Standard Telephones and Cables Limited has just been installed. It is provided with both card and paper tape input and output, and allows either punched cards or punched tape to be used for recording the tunnel results. It will, of course, serve the new supersonic tunnel as well as the transonic facilities.

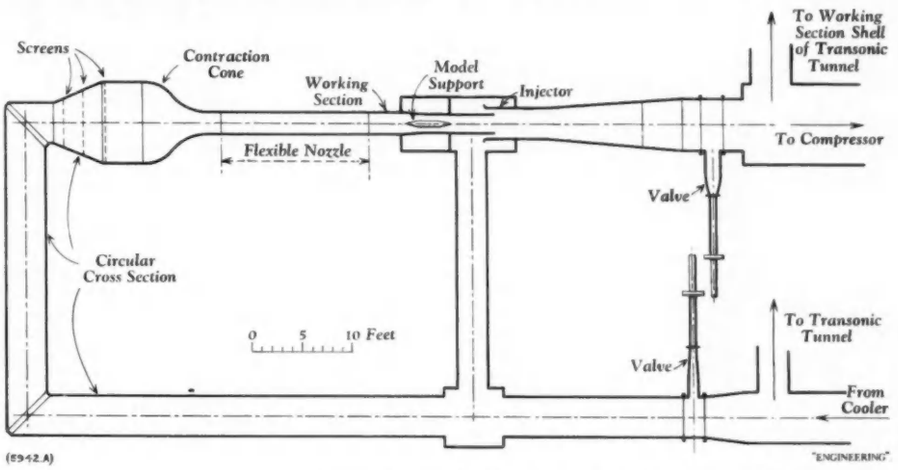
MACH 3·5 TUNNEL

Turning now to the new supersonic tunnel: it has a working section 2½ ft high by 2¼ ft wide and will permit tests on models of up to 2 ft in length. The pressure range is from ¼ to 1½ atm. absolute. The axial compressor which drives it has eleven stages with a total power of 13,750 h.p. and is normally used as a suction plant on the transonic tunnel to enable it to run above the speed of sound. By operating motorised valves the compressor can be isolated from the transonic tunnel and then run on a separate circuit with the supersonic tunnel. Both tunnels can be run at the same time provided the transonic tunnel is not required to go above Mach 1. Since in most model tests in the transonic tunnel a considerable amount of testing is done below Mach 1, there will be plenty of time available for running the compressor on the supersonic tunnel, and the whole plant can be used in the most efficient manner. The changeover from one tunnel to the other by the motorised valves only takes a few minutes.

If a supersonic tunnel of constant working section size is coupled directly to an axial compressor the flow given by the compressor will not match that required by the tunnel over a range of Mach numbers. The tunnel working section size must be chosen so that the compressor volume flow is sufficient to run it at the lowest Mach number required and the compressor will then provide more volume flow than is necessary at the higher Mach numbers. This characteristic can be utilised by providing an injector slot in the diffuser downstream of the working section and by passing the excess air from the compressor round the working section into this injector.

In the ARA tunnel the working section size is chosen to match the volume flow at Mach 1·4 and the compressor gives an excess flow of about 120 per cent of the flow required through the working section at Mach 3·5. This air is injected into the diffuser at a local Mach number of 1·7 and its injector action considerably decreases the overall pressure drop between the entry to the working section and the exit from the diffuser. Model tests made on a 4 in square supersonic tunnel showed that with injection a pressure ratio of 3·6 was required for a Mach number of 3·4, compared with an estimated pressure ratio of about 5 without injection. Since the top pressure ratio on a compressor is limited by surging, the Mach number using injection will be higher than that obtainable in a tunnel without injection. Based on these results, the ARA supersonic tunnel has been designed for a Mach number range from 1·4 to 3·5. The compressor, however, is capable of pressure ratios up to 4·2, higher than available in the model tests, and provision has been made for an extension of the Mach number in the actual tunnel to 4 if this proves possible.

The tunnel circuit is shown in the accompanying diagram. The air from the compressor cooler goes through a 4 ft diameter motorised valve which is one of the two isolating valves for the supersonic tunnel circuit. It then passes through a banjo type junction where the by-pass air is fed to the injector. Just upstream of the contraction cone the tunnel section expands rapidly (45° total cone angle) using three spaced gauze screens which prevent separation in the wide angle diffuser. A fixed contraction is followed by the nozzle section which has flexible walls on the top and bottom with fixed parallel walls on the sides.



Layout of the ARA 2 ft 6 in by 2 ft 3 in supersonic wind tunnel.

The flexible walls are designed to give the exact nozzle shape for a Mach number range from 1·4 to 4. They can be adjusted over the full range while the tunnel is running, in 2½ minutes. The nozzle is shown in the illustration on page 188, with one sidewall removed to reveal the mechanism. The top and bottom flexible walls are supported from large beams running the whole length of this section and pivoted at their downstream ends (left). The upstream end of the flexible plate is permanently bent round a rigid former which is held at its downstream end by a link on the beam and at its upstream end by a linkage to a roller moving in a cam. Downstream of this former, or throat block, each flexible plate is supported by a number of links whose vertical heights are fixed by rollers moving in cams mounted in horizontal slides on to the beam.

The upstream end of the beam can be moved up and down by a screw jack driven by a hydraulic motor. As it moves, a linkage system fixed to the tunnel structure causes the cams to move horizontally, and so alter the heights of the links relative to the beam to adjust the shape of the flexible plate. At the same time movement of the roller in the front cam causes the former block to move to a new angle relative to the beam. There is therefore sufficient adjustment in the system to give the correct nozzle shape for every Mach number, in 0·1 steps, over the range

Continuing **Design**

Mach 1·4 to 4—in fact, a virtually continuous variation. The edges of the flexible plate which slide over the side walls are sealed by polythene strips fitted in grooves and pressed against the side walls by a soft rubber backing strip.

The chamber behind the flexible plate is vented to working section pressure so that the pressures across the plate are small. A fairly thin plate, $\frac{3}{8}$ in, can therefore be used, and the loads on the rollers and cams due to the bending of the plate and to air loads are small. This is the main reason why it has proved possible to use a design of this type instead of the more conventional arrangement with individual screw jacks controlled by an expensive servo mechanism. Mechanically the design has proved very satisfactory and control of the throat size can be obtained eaily to less than $\pm$ 0·002 in while the whole nozzle shape is within $\pm$ 0·005 in of the theoretical for all Mach numbers. From the limited calibration which has already been done, the flow appears to be very uniform and the Mach number at the centre of the tunnel varies by less than 0·01 from the design value.

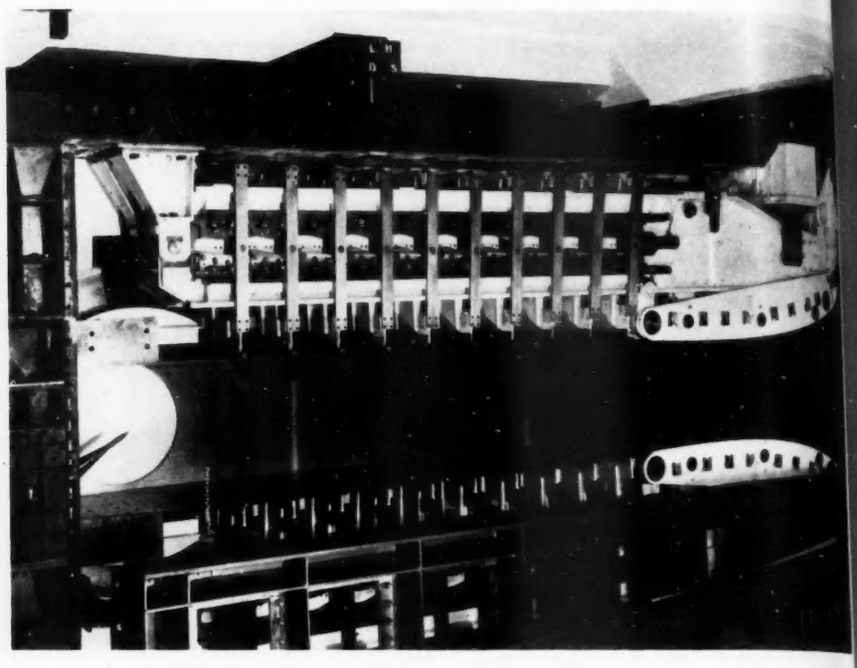
In the working section two 2 ft diameter windows with schlieren quality glass enable flow photographs to be taken with a spark source, and allow continuous observation of schlieren and shadowgraph. The model support consists of a quadrant and sting. The incidence variation is obtained by hydraulic rams over a range from $-$ 10° to $+$ 45°. The whole incidence range can be traversed in 25 seconds, and a stepping device is provided which automatically steps on the incidence a predetermined number of degrees each time a button is pressed. Roll over the range 0° to 360° is provided on the model by a rolling unit fitted between the sting and quadrant.

Downstream of the working section the top and bottom walls of the diffuser are fixed and approximately parallel, but the side walls are divided into a number of hinged sections, each section being held in position by a hydraulic ram. The rams can be adjusted while the tunnel is running to give the best possible diffuser configuration for any Mach number. The injector slot is fitted as part of this system and the amount of air injection can be changed by adjustment of the appropriate hydraulic rams to alter the width of the slot.

At the end of a further section of the fixed diffuser there is a 5 ft diameter valve which is the second main isolating valve in the supersonic tunnel circuit. Downstream of this the section expands to an 8 ft diameter collecting chamber immediately ahead of the compressor. In this section a metal honeycomb, backed by a gauze screen, has been built to provide a safeguard against any parts of a model flying into the compressor.

The tunnel can be run over a stagnation pressure range from $\frac{1}{4}$ to $1\frac{1}{2}$ atmospheres. It is normally started at low pressure to avoid a large shock load on the model. Dry air is stored in a separate tank at 10 atmospheres pressure and is used to raise the pressure in the tunnel circuit. The dry air is supplied by compressing air to 10 atmospheres, cooling, removing the water and then passing it through a dryer. Under running conditions sufficient air is bled into the tunnel circuit from the dry air store to maintain dry air in the tunnel circuit.

The measurements of the aerodynamic forces on models are made by strain gauge balances mounted either inside the model or on the attachment sting. Signals from the strain gauges are fed to d.c. servo balancing potentiometers which plot the resulting readings on a chart (against incidence) for visual inspection, and at the same time feed a digitised voltage in binary form to a card punch. Eight channels are normally provided; they can be supplemented by further channels, if required, and up to 20 quantities can be recorded on each card. The cards can then be fed directly into a computer which corrects the results into the standard non-dimensional coefficient form, and works out all sting deflections and other relevant details.



The flexible nozzle section with one sidewall removed to reveal the cam and linkage mechanism for varying the shape of the top and bottom walls.

A calibration frame is provided for calibrating the strain gauge balances. It uses a series of levers with dead weights so that forces and moments can be applied in three directions while the electrical signals are fed to the same servo balancing potentiometers and card punch system to record the readings which can then be worked out directly on the computer. In order to ensure that the directions of the forces which are applied are accurately known, the balance is mounted in a rig with means of adjusting its level in the horizontal and vertical planes under different loads. The measurements of level are made by using standard workshop dial indicators reading to 0·001 in. Using this equipment a balance measuring three components of force and three moments can be calibrated and all linear interactions measured in a few hours.

Pressure measurements can be made by photographing normal manometers or by using several Scanivalve pressure switches which switch a number of pressure points to a single pressure transducer. This transducer records on a d.c. servo balancing potentiometer giving a chart record for visual observation and also feeds the results on to a punched tape for transfer to the computer.

SUMMARY OF PLANT PERFORMANCE

Compressor
Axial compressor with 11 stages.
Volume flow at intake 290,000 cu. ft per minute.
Pressure ratio: maximum at surge 4·2 : 1.
Speed: 3,000 r.p.m.
Motor: synchronous 1,000 r.p.m. with 13,750 h.p. for 2 hours.

Auxiliary Plant
Evacuation compressor:
90 h.p. positive displacement rotary type.
Intake volume flow 1,200 cu. ft per min with pressure ratio 5:1
Trimming compressor:
45 h.p. positive displacement rotary type.
Intake volume flow 730 cu. ft per min.
Pressure ratio 1·5 : 1.
Dryer plant:
90 h.p. piston type.
Intake volume flow 400 cu. ft per min up to 150 lb per sq. in pressure.
Alumina dryer working at 150 lb per sq. in, giving dew point of $-$40° C on outlet at a flow rate of $\frac{1}{2}$ lb per sec.

List of Manufacturers.—Tunnel working section and flexible nozzles, Hall Engineering Ltd.; tunnel duct work, G. A. Harvey & Co. Ltd.; axial compressor, British Brown-Boveri; 13,000 h.p. synchronous motor, English Electric Co. Ltd.; main cooler, Serck Radiators Ltd.; evacuation compressor, James Howden & Co. Ltd.; trimming compressor, Sir George Godfrey & Partners Ltd.; motorised valves, Rotork Engineering Co. Ltd.; dryer compressor, Broom & Wade Ltd.; dryer, Birlec Ltd.; Schlieren windows, Pilkington Bros. Ltd.; Schlieren mirrors, Optical Works Ltd.; d.c. strain gauge bridge recorders, Integra, Leeds & Northrup Ltd.; Zebra Computer, Standard Telephones & Cables Ltd.; hydraulic equipment, Keelavite Rotary Pumps & Motors Ltd.

DIMENSIONS OF BALL AND PARALLEL-ROLLER BEARINGS

The British Standard on dimensions of ball and parallel-roller bearings has recently been revised and is now issued as BS292:1958. It relates to those features which control the interchangeability of bearings as units; it does not deal with their internal dimensions or with detailed design.

Dimensions are specified for single-row, angular contact and double-row journal bearings; for rigid, parallel-roller, journal bearings; for snap-ring type ball journal bearings; for magneto bearings, and for single-thrust bearings with flat seatings and with spherical seating rings. Inch and metric sizes are provided up to 30 in and 400 mm bore, respectively, though not as equivalents. The tolerances on the external dimensions, diametral clearance, and permissible errors due to wobble and eccentricity are specified, as are fillets and shoulder heights for metric journal bearings. A standard nomenclature for the component parts of bearings is included, with the British Standard reference symbols for each type and size of bearing.

Copies may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1 (12*s* 6*d*).

MEETINGS AND PAPERS

Association of Supervising Electrical Engineers

LONDON
"Time-Controlled Telephones," by H. E. J. Butler. Central London Branch. White Hall Hotel, Bloomsbury Square, W.C.1. Mon., 9 Feb., 7.15 p.m.

GLASGOW
Discussion on "Servicing Auto-Electrical Systems." Glasgow Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Wed., 11 Feb., 8 p.m.

British Institution of Radio Engineers

LONDON
"Instrument Problems in Medical Electronics, with Particular Reference to Electromyography," by Peter Styles. Medical Electronics Group. London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1. Fri., 13 Feb., 6.30 p.m.*

NEWCASTLE UPON TYNE
"Stereophonic Sound from Records," by P. B. Cooper. North Eastern Section. Neville Hall, Westgate Road, Newcastle upon Tyne. Wed., 11 Feb., 6 p.m.

WOLVERHAMPTON
"Some Aspects of the Control of Nuclear Reactors," by Dr. L. W. J. Newman. West Midlands Section. Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton. Wed., 11 Feb., 7.15 p.m.

Chemical Engineering Group

LONDON
"Extraction of Thorium," by W. D. Jamrack, R. A. Wells and Dr. J. H. Buddery. Tues., 10 Feb., 6 p.m.

Chemical Society

LONDON
"Polyacetylenes," by Professor E. R. H. Jones. Imperial College of Science and Technology, South Kensington, S.W.7. Thurs., 12 Feb., 7.30 p.m.

Engineers' Guild

GLASGOW
"Artificial Satellites," by P. Tanner. Luncheon Meeting. West of Scotland Branch. Georgic Restaurant, Union Street, Glasgow. Mon., 9 Feb., 12.30 for 12.45 p.m.

Illuminating Engineering Society

MANCHESTER
"An Analytical Approach to Industrial Lighting," by W. Imrie-Smith. Manchester Centre. Offices of the North Western Electricity Board, Town Hall Extension, Manchester 2. Thurs., 12 Feb., 6 p.m.

Institute of Fuel

LONDON
"Industrial Use of Small Coal," by J. N. Williams. Institution of Civil Engineers, Great George Street, S.W.1. Wed., 11 Feb., 5.30 p.m.*

Institute of Marine Engineers

BRISTOL
"The Design and Building of Icebreakers," by A. Watson. West of England Section. Grand Hotel, Bristol. Mon., 9 Feb., 7.30 p.m.

GLASGOW
Annual General Meeting. "Care and Maintenance of High Pressure Water-Tube Boilers and Ancillary Equipment," by W. R. Harvey. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Wed., 11 Feb., 7.30 p.m.

KINGSTON-UPON-THAMES
"Construction of the Ship," by G. Ridley Watson. Kingston Technical College, Fassett Road, Kingston-upon-Thames. Wed., 11 Feb., 2.15 p.m.

Institute of Metals

GLASGOW
Open Meeting. Scottish Local Section. 39 Elmbank Crescent, Glasgow, C.2. Mon., 9 Feb., 6.30 p.m.

Institute of Road Transport Engineers

BIRMINGHAM
"Recent Developments in Fuel-Injection Pump Design," by T. G. Charlesworth. Midlands Centre. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham. Tues., 10 Feb., 7.30 p.m.

MAIDSTONE
"Taking Stock on Maintenance," by P. H. Wyke Smith. Southern Centre. Royal Star Hotel, Maidstone, Kent. Wed., 11 Feb., 7.30 p.m.

NOTTINGHAM
Discussion on "Road Transport Law." East Midlands Centre. Mechanics' Institute, Nottingham. Wed., 11 Feb., 7.30 p.m.

Institution of British Agricultural Engineers

ESSENDINE (STAMFORD)
Discussion on "Uses of Plastics in Agriculture." East Midlands Centre. Canteen of Allis-Chalmers (Great Britain) Ltd., Essendine, near Stamford, Lincs. Wed., 11 Feb., 7.30 p.m.

Institution of Chemical Engineers

LONDON
Symposium on "Mass Transfer." Church House, Dean's Yard, S.W.1. Thurs., 12 Feb., 9.30 a.m.

Institution of Civil Engineers

LONDON
"Automatic Analysis of Steel-Framed Structures under Fixed and Varying Loads," by Jacques Heyman. Tues., 10 Feb., 5.30 p.m.*

CHESTER
"Connahs Quay Power Station," by F. W. Evans. North Western Association. Queen Hotel, Chester. Thurs., 12 Feb., 7.30 p.m.

MANCHESTER
"Housing the Dounreay Fast Reactor," by N. T. Barrett. North Western Association. College of Science and Technology, Manchester. Tues., 10 Feb., 6.30 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Dissemination and Assimilation of Technical Literature—A Growing Problem," opened by J. K. Webb. Mon., 9 Feb., 5.30 p.m.*
"Discrimination Between High Rupturing Capacity Fuses," E. Jacks. Utilization Section. Thurs., 12 Feb., 5.30 p.m.*
Discussion on "Some Reasons for Failure in the Part III Examination," opened by Professor M. G. Say. Education Discussion Circle. Fri., 13 Feb., 6 p.m.*

BELFAST
"Design of the 330 kV Transmission System for Rhodesia," by F. C. Winfield, T. W. Wilcox and G. Lyon. Northern Ireland Centre. David Keir Building, Queen's University, Stranmillis Road, Belfast. Tues., 10 Feb., 6.30 p.m.

GLASGOW
"Pattern Recognition by Means of Automatic Analogue Apparatus," by Dr. W. K. Taylor; and "A System for the Automatic Recognition of Patterns," by Dr. R. L. Grimsdale and others. South West Scotland Sub-centre. Royal College of Science and Technology, George Street, Glasgow, C.1. Tues., 10 Feb., 7 p.m.

LEEDS
Discussion on "Co-operation Between College and Industry on Industrial Training Schemes," opened by K. J. Martin. North Midland Centre. Offices of the Central Electricity Generating Board, Leeds. Tues., 10 Feb., 6.30 p.m.

NEWCASTLE UPON TYNE
"The Deltic Locomotive," by C. M. Cock. North Eastern Centre. Neville Hall, Westgate Road, Newcastle upon Tyne. Mon., 9 Feb., 6.15 p.m.

SOUTHAMPTON
Faraday Lecture on "Automation," by Dr. H. A. Thomas. Southern Centre. Guildhall, Southampton. Mon., 9 Feb., 6.30 p.m.*

Institution of Engineering Designers

NEWCASTLE UPON TYNE
"Engine Room Layout," by J. A. Hardy. North East Branch. Northern Architectural Association's hall, 6 Higham Place, Newcastle upon Tyne 1. Mon., 9 Feb., 7.15 p.m.

Institution of Engineering Inspection

LONDON
"Three Co-ordinate Tape Controlled Inspection System," by H. J. Elton. Royal Society of Arts, John Adam Street, Adelphi, W.C.2. Wed., 11 Feb., 6.45 p.m.*

Institution of Heating and Ventilating Engineers

CARDIFF
"Experience with the Heat Pump in Great Britain," by Miss M. V. Griffith. South Western Branch. GEC Building, Cardiff. Tues., 10 Feb., 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Open Meeting of the Automobile Division. Tues., 10 Feb., 6 p.m.*
Discussion on "Future Vehicle Power and Torque Requirements in Home and Export Markets." Joint Meeting of the Internal Combustion Engine Group and the Automobile Division. Wed., 11 Feb., 6 p.m.*
"Induction Ramming of Small High-Speed Air Compressor," by Professor F. K. Bannister. Meeting in conjunction with the Applied Mechanics Group. Fri., 13 Feb., 6 p.m.*

ABERDEEN
"Some Engineering Aspects of Nuclear Energy Developments, by A. T. Bowden. Scottish Branch. Robert Gordon's College, Aberdeen. Fri., 13 Feb., 7.37 p.m.

DUNDEE
"Some Engineering Aspects of Nuclear Energy Developments," by A. T. Bowden. Scottish Branch. Technical College, Dundee. Thurs., 12 Feb., 7.30 p.m.

LEEDS
"Ductility in Aluminium Castings," by R. Mercer. Yorkshire Branch. The University, Leeds. Thurs., 12 Feb., 6.30 p.m.

Institution of Production Engineers

LEICESTER
Annual General Meeting at 7.15 p.m. "Friction and Lubrication in Production Plant Spindles and Bearings," by T. N. Bennett, at 7.45 p.m. Leicester Section. Grand Hotel, Leicester. Thurs., 12 Feb.

LIVERPOOL
Discussion on "Statistics: Operational Research." Liverpool Section. Exchange Hotel, Tithebarn Street, Liverpool 2. Wed., 11 Feb., 7.30 p.m.

Institution of Railway Signal Engineers

YORK
"Colour-Light Signalling Principles, Including the Application of Central Train Control," by D. G. Parker. York Centre. Signalling School, Toft Green, York. Thurs., 12 Feb., 5.30 p.m.*

Institution of the Rubber Industry

LONDON
"What Makes Rubber Strong?" by Dr. L. Mullins; and a discussion on research topics. London Section. National College of Rubber Technology, Holloway, N.7. Tues., 10 Feb., 5.30 p.m.

Junior Institution of Engineers

LONDON
Honorary Member's Lecture on "Energy Demands and a Fuel Policy," by Dr. J. G. King. Fri., 13 Feb., 7 p.m.*

Leeds Metallurgical Society

LEEDS
"Operational Research in the Steel Industry," by D. Jordan. Chemistry Wing, The University, Leeds 2. Thurs., 12 Feb., 7.15 p.m.

Liverpool Engineering Society

LIVERPOOL
IME Thomas Lowe Gray Lecture on "Marine Refrigeration," by H. R. Howells. Wed., 11 Feb., 6 p.m.

Liverpool Metallurgical Society

LIVERPOOL
"Russian Steel Industry," by R. Wilcock. Department of Metallurgy, University of Liverpool, 146 Brownlow Hill, Liverpool 3. Thurs., 12 Feb., 7 p.m.

Manchester Association of Engineers

MANCHESTER
"Marine Salvage and Salvage of the Empress of Canada," with film, by W. R. Colbeck. Engineers' Club, Albert Square, Manchester. Fri., 13 Feb., 6.45 p.m.

Newcomen Society

LONDON
"Inventions of Ettore Bugatti," by H. G. Conway. Wed., 11 Feb., 5.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE UPON TYNE
"Manufacture of Marine Oil Engines," by J. E. Smith. Neville Hall, Westgate Road, Newcastle upon Tyne. Fri., 13 Feb., 6.15 p.m.

Physical Society

LONDON
"Some Problems in the Handling and Distribution of Liquefied Gases," by Dr. T. J. Webster. Low Temperature Group. Royal School of Mines, Prince Consort Road, S.W.7. Wed., 11 Feb., 4 p.m.

Royal Aeronautical Society

LONDON
"Earth Satellites," by W. H. Stephens. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Thurs., 12 Feb., 6 p.m.*

Royal Society of Arts

LONDON
"History of the African Pyrethrum Industry," by Dr. T. F. West. Tues., 10 Feb., 5.15 p.m.*

Royal Society of Health

LONDON
"Clean Air Act, 1956; Technical Factors in Its Implementation," by Dr. A. Parker, W. J. Dickie and J. Graham. Caxton Hall, off Victoria Street, S.W.1. Thurs., 12 Feb., 2.30 p.m.

Royal Statistical Society

LONDON
"An Introduction to Information Theory: An Illustrated Non-Technical Outline," by Professor Colin Cherry. General Applications Section. 28 Portland Place, W.1. Wed., 11 Feb., 6.15 p.m.*

Sheffield Metallurgical Association

SHEFFIELD
"Refractories and the Oxygen Steelmaking Process," by J. L. Harrison and D. W. N. Pitts. BISRA Laboratories, Hoyle Street, Sheffield. Tues., 10 Feb., 7 p.m.

Society of Chemical Industry

LONDON
"Recent Research on the Corrosion of Tinplate," by S. C. Britton and K. Bright. Corrosion Group. Wed., 11 Feb., 6.30 p.m.

Society of Instrument Technology

LONDON
"A Digital Instrumentation System for Use in the Testing of Jet Engines," by L. Airey. Data Processing Section. Manson House, Portland Place, W.1. Wed., 11 Feb., 6 p.m.*

West of Scotland Iron and Steel Institute

GLASGOW
"Operational Research with Particular Reference to Open-Hearth Charging," by J. Banbury. Fri., 13 Feb., 6.45 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this feature should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
Chemical Engineering Group, 14 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Engineers' Guild, 78 Buckingham Gate, London, S.W.1. (ABBey 7315.)
Illuminating Engineering Society, 32 Victoria Street, London, S.W.1. (ABBey 5215.)
Institute of Fuel, 18 Devonshire Street, Portland Place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave Square, London, S.W.1. (BELgravia 3291.)
Institute of Road Transport Engineers, 69 Victoria Street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 6 Buckingham Gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland Place, London, W.1. (LANgham 8847.)
Institution of Engineering Inspection, 28 Victoria Street, London, S.W.1. (ABBey 3794.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield Street, London, W.1. (GROsvenor 5254.)
Institution of Railway Signal Engineers. Apply to Mr. R. L. Weedon, 222 Marylebone Road, London, N.W.1. (AMBassador 7711.)
Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W.8. (BAYswater 9101.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1. (VICtoria 0786.)
Leeds Metallurgical Society. Apply to Dr. P. Feltham, The University, Leeds.
Liverpool Engineering Society, 9 The Temple, 24 Dale Street, Liverpool 2. (Central 3717.)
Liverpool Metallurgical Society, Greenhithe, Grosvenor Road, St. Helens, Lancs. (St. Helens 5879.)
Manchester Association of Engineers, 18 Booth Street, Manchester 2. (Central 1717
Newcomen Society, Science Museum, Exhibition Road, London, S.W.7. (KENsington 1793.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne 1. (Newcastle 20289.)
Physical Society, 1 Lowther Gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Royal Aeronautical Society, 4 Hamilton Place, London, W.1. (GROsvenor 3515.)
Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Society of Health, 90 Buckingham Palace Road, London, S.W.1. (SLOane 5134.)
Royal Statistical Society, 21 Bentinck Street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield 7. (Sheffield 52865.)
Society of Chemical Industry, 14 Belgrave Square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne Street, London, W.1. (LANgham 4251.)
West of Scotland Iron and Steel Institute, 39 Elmbank Crescent, Glasgow, C.2. (Central 5181.)

Construction

BRADFORD RECONSTRUCTS

the City Centre

The proposed appearance of Bradford's central development area in five years' time

The redevelopment of the centre of Bradford has been begun. For the sole purpose of bringing into being a city centre that is in keeping with the times, about 10 acres of existing buildings are to be demolished and replaced by modern blocks. About 1 million sq. ft of new shop and office accommodation are to be provided and, as the illustration shows, the project includes an elevated car park giving access to the first floor of shops and offices.

The scheme is expected to take five years to complete and to cost £5 million. Unlike many other British cities, Bradford suffered little from war-time bombing so there was no widespread destruction to prompt the replanning. The intention is to provide a city centre to serve the population of 300,000, the development forming a major part of an overall plan for Bradford that the Corporation produced under the 1947 Town and Country Planning Act. During the past five years, 4 million sq. ft of new industrial floor space has been authorised within the area of the city but, because of the two world wars and the depression of the 1930's, the development of the centre has lagged behind the growth of the suburbs. The Corporation has entered into an agreement with the Hammerson Property and Investment Trust to undertake the work.

Before commencing the work a number of difficulties had to be resolved. First retailers had to be persuaded to move from established shopping streets. This has been done and several multiple retailers of national repute—including W. H. Smith, the newsagents—have entered into the scheme. Also, through the centre of the city, there runs a river, the Beck; although this was put underground when the existing buildings went up, more work has been completed to ensure that subterranean streams do not impede new building.

Trunk roads are required to serve the new centre and the Ministry of Transport has approved the Corporation's plans which will, happily, give a much improved view of Bradford Cathedral. Originally it was intended that the main shopping street should be 80 ft wide; resistance from retailers, who collectively are opposed to wide streets, has caused the Corporation to accept a narrower width of 60 ft. A system of inner ring roads is to be provided for the through traffic. The car park, already mentioned, will take 200 cars and will be reached by easy ramps which will be heated when necessary to prevent icing up.

Responsibility for the overall planning is carried by the City Engineer, Mr. S. G. Wardley, M.I.C.E., and the Public Works Committee.

WHERE STEEL HAS NO EQUAL

Suspension Bridge Engineering described in First Maitland Lecture

The first Maitland Lecture at the Institution of Structural Engineers was given by Mr. O. A. Kerensky, B.Sc., M.I.Struct.E., M.I.C.E., on Thursday, 22 January last. Mr. Kerensky, who is a partner in Freeman, Fox and Partners, the London consultants, took as his subject "Modern Large-Span Suspension Bridges."

The Maitland Lecture has been established to honour the name of Major R. F. Maitland, O.B.E., secretary of the Institution since 1930. The subject may be on research, design or construction in the field of structural engineering, with special reference to new developments. It will be competed for annually by corporate members of the Institution and the winner will receive the Maitland Silver Medal and a premium award of £100, The council has retained the right to nominate the lecturer once in three years. Submissions for next year's lecture have to reach the Institution by 15 April next.

It was in 1855 that American John A. Roebling wrote—as a lecturer reported—" bridges of half-a-mile span, for common or railway travel, may be built, using iron for the cables, with entire safety. Eut by substituting the best quality of steel wire, we may nearly double the span and afford the same degree of security." Today the means of erecting the cables are still much as Roebling suggested. Stranded wire cables are still of the form that Roebling devised, and so are the methods of protecting them. Mr. Kerensky reported that a 70-year-old cable has recently been opened up and found to be in excellent condition. An improved pattern of the Roebling equipment was expected to be used for the new Forth bridge.

Much of the lecture was devoted to examining the complexities of design and erection of this bridge form—which became economical as the main span exceeded 1,600 ft. The involved conditions arising from partial loading under varying wind loads that might produce maximum stresses, and the selection of efficient members for the cable, the towers and the deck truss, were matters for trial and error design calling for an immense amount of arithmetic. As one questioner elicited after the lecture, the electronic computer had much to offer the suspension bridge designer: after a small trial change of a member or loading it would be straight forward to compute the effect. Nevertheless, Mr. Kerensky emphasised the only adequate approach to eliminating catastrophic oscillation under wind loading was the use of model tests in a wind tunnel.

Following other questions Mr. Kerensky's listeners learnt that 70 ton steel wires, 0·2 in in diameter, could be butt welded to form the cables and that neither aluminium nor concrete had anything to offer the designer of such bridges. It was steel—and for the most part high tensile steel—that could be best deployed to effect lightness yet sufficient stiffness to resist wind loading. The lecture will probably be published in the May issue of the *Structural Engineer*.

ELEVATED ROADWAYS

Competition for Concrete Design

The Prestressed Concrete Development Group invites designs for lengths of elevated roadway to be entered for a competition. The design which shows the greatest merit will be awarded a prize of £500; another £500 will go, at the discretion of the assessors, to any other competitor or competitors whose designs merit an award.

The designs must be based on the use of prestressed concrete, either on its own or in conjunction with reinforced concrete, and result in safe, attractive structures. The treatment is required to show

(1) an elevated road on the same line as an existing road and carried above it on piers located in the central strip between the carriageways of the lower road on which traffic will continue during and after construction; and (2) a length of this road short circuiting a section of the lower road so that a more economic arrangement of the supports can be adopted, limited only by the requirement that the area below the higher road forms a car park.

Full details of the competition and specifications to be assumed can be obtained from the Prestressed Concrete Development Group, Terminal House, Grosvenor Gardens, London, S.W.1. Competitors' designs must reach the Group not later than 30 June, 1959.

Among the five assessors is Colonel G. W. Kirkland, formerly president of the Group. The January issue of the *Structural Engineer* contains the excellent paper "Urban Motorways" that Colonel Kirkland read before the Institution of Structural Engineers early last month.

URBAN ROADWAYS

An exhibition of photographs and models of urban roads, staged jointly by the British Road Federation, Shell Mex and B.P. Limited, and the Prestressed Concrete Group, was opened by the Minister of Transport at the Institution of Civil Engineers on Wednesday, 28 January. The exhibition is to close on 6 February.

Entitled "Town Roads for Today—and Tomorrow," the exhibition showed examples of many projects which have been built and planned for tackling urban traffic congestion both overseas and in this country. A small booklet published by the BRF and having the same title as the exhibition, was given to every visitor. It gives brief notes, city by city, of work in hand to provide a better road system.

Operation and Maintenance

DIRECT HEATING OF FUEL OIL

Lower Operating Costs for Large Installations

In large works, such as power stations, using oil-fired boilers operating on heavy viscous fuel oil, the conventional practice is to use a steam/oil heat exchanger, fed from a small auxiliary steam plant, to heat the fuel oil up to firing conditions. The steam plant, involving boilers, steam tracing, steam trapping, condensate handling, and feed-water treatment, demands a fair amount of maintenance work, and the heat losses are quite high. An estimated overall thermal efficiency has been given as some 50 to 60 per cent.

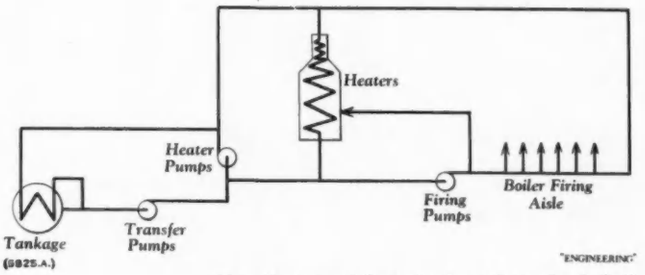
With a view to improving the efficiency and providing a simpler installation, Foster Wheeler Limited, 3 Ixworth Place, London, S.W.3, have worked out a scheme for directly heating fuel oil up to firing conditions without the use of steam or electricity for heating purposes. It is intended for reasonably compact installations having a total heating load of 10 million Btu per hour minimum, using fuel oil with viscosities up to 6,000 seconds Redwood No. 1 at 100° F and possibly higher.

The basic scheme is shown in the accompanying flow diagram. Direct-fired heaters are employed, and provision is made for heating the tankage by a coil, and offsetting heat losses from the piping, without using other heating medium.

The type of heater envisaged is similar to those developed by Foster Wheeler for use in oil refineries, using pressure-atomising oil burners, although steam-atomising burners would be equally satisfactory. Either the vertical type of heater, in which the heat-exchanger tubes are mounted vertically in a cylindrical casing, or a cabin-type heater with horizontally-mounted tubes in a rectangular casing, can be used. In both cases, the burners are mounted in the floor of the heater to give upward firing. Variable-delivery transfer and heater pumps are employed to ensure that the flow through the heater is maintained at a given value with optimum efficiency. The heated oil flowing from the heaters is raised to burner pressure by high-pressure firing pumps.

The first cost of an installation of this type is much the same as that of a conventional system employing steam heating, but overall thermal efficiencies up to 80 per cent are said to be possible, and maintenance costs would be appreciably less.

As already mentioned, the basic scheme is intended for compact plants, but a variation could be applied to wide-spread installations. This would, however, require steam or electric tracing of the fuel-oil pipelines to maintain the required temperature.



Flow diagram of direct heating scheme for fuel oil.

The type of heater envisaged is similar to those used in oil refineries—either the cylindrical type seen on the left and surmounted by the stack, or the cabin-type seen on the right behind the stack.

SEEING ROUND THE CORNER

Closed circuit television is finding increasing use in industry, but its potential applications are so many that a vast field remains, at present, unexplored. A summary of the available equipment, illustrated by examples of its use in iron and steel works, has been prepared by the British Iron and Steel Research Association,* and although written primarily for one particular industry, it shows how varied and versatile the equipment now on the market can be.

In its simplest form an industrial television installation consists of three units connected by cables; the camera, the camera control unit, and the picture display unit or monitor. The cameras available as standard items are quite small—less than a foot long and 4 in or 5 in in width and height. Most of them can be operated at temperatures up to 45 or 50° C (113 to 122° F) without modification, and forced cooling equipment can be supplied when the camera is to be used in hotter places. Dustproof and weatherproof housings are available.

All the equipment necessary for controlling the camera is grouped in a single unit, which, again, is quite small, occupying only 1 or 2 cu. ft of space, and can be placed wherever it is most convenient. The usual position for the control unit is beside the monitor screen. Connection between the control unit and the camera is by multi-core cable, which can be up to 300 ft long.

Monitor screens are available in sizes from 5 in to 27 in (measured across the diagonal of the picture) and projection receivers can be used to provide pictures from 2 ft by 4 ft to full cinema size; the latter must be viewed under conditions of complete black-out. There is a choice of three standards for the display unit; the British 405 line, the American 525 line, or the European 625 line. For many purposes the 405 line standard is adequate, but one of the others may be used when it is necessary to observe fine detail. Several monitors can be fed from the same camera control unit.

The maximum distance between the control unit and the monitor depends on the type of transmission adopted. It is possible to transmit a signal up to 3,000 ft from the camera control unit.

Many accessories are available to increase the usefulness of the equipment. It is possible, for example, to provide remote-controlled movement for the camera, which will enable it to make a horizontal or a tilting movement (or both) at the will of an operator, and with varying degrees of precision according to need. Lens selection, focusing and iris diaphragm control can all be effected remotely. It is usually possible to obtain adequate pictures with the existing illumination but it is suggested that a light equal to 100 to 150 ft-candles is desirable.

Many uses have been found for closed circuit television; many more are undoubtedly possible. An obvious one is to extend the field of view of an operator so that he can see objects that would otherwise be hidden from him. Thus a machine operator can be shown a remote or hidden point of his machine and so can operate it more efficiently or more safely. A furnace-man can be given a view of the furnace stack and of any

* Summary 130. "Television in the Steel Industry", British Iron & Steel Research Association, 11 Park Lane, London, W.1.

Continuing

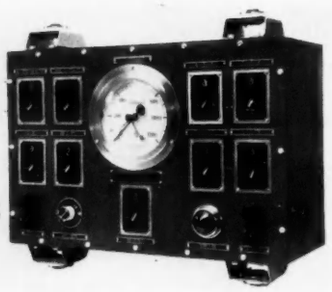
Operation and Maintenance

smoke emitted. Similarly, rolling mill operators can be shown both sides of the mill simultaneously, and this, of course, applies to any large machine or group of machines where a man cannot see all the points of importance unaided. As the television camera is quite small, it can be used for inspection of many things that would be difficult or impossible of access for human beings. In addition, when the required viewpoint is likely to be dangerous, television is ideal.

SAFE OPERATION *of* COMPRESSORS

Advance warning of abnormal running conditions on air compressors, followed by automatic shut-down before dangerous conditions are reached, are provided by protection equipment developed by Teddington Industrial Equipment Ltd, Sunbury-on-Thames, Middlesex, in co-operation with the National Coal Board and leading compressor manufacturers.

The equipment consists of a panel mounted on the compressor and, for underground use, a flameproof indicating unit, rotary switch, and alarm bell. For surface installations the separate indicator unit is replaced by a series of latched fault indicators in the panel itself. Several variations are possible to suit particular requirements, and the equipment is easily fitted to new or existing compressors.



In operation the motor starter circuit is completed when a rotary switch, incorporated in the panel, is turned to the "on" position. Provided that normal oil pressure is reached within 20 seconds, the current will then be maintained through the protection switches and shut-down relays.

If the L.P. or H.P. discharge temperatures rise abnormally, a warning bell will be sounded and a lamp illuminated. Advance warning is thus given, and if corrective action is taken before conditions deteriorate, the relays will re-set automatically, and the alarm will cease to operate. If, however, either temperature rises to danger level, the machine will be shut down. No advance warning is given of loss of coolant, or of falling lubricating oil pressure; in either case the compressor will be stopped.

The protection panel fails to safety in the event of a fault or damage, and if there is a mains failure or an earth fault the shut-down equipment will operate at once.

Engineering at Home

SIMPLIFIED CENTRAL HEATING

A method of electric floor warming has been developed through the experimental work of the Eastern Electricity Board on a pioneer installation in their offices at Wherstead, near Ipswich.

The usual pre-requisite for electric floor warming is a concrete floor, which has a high thermal inertia and can usefully store off-peak energy. Whilst in certain circumstances it is possible to instal the system in an existing building possessing this type of floor, it is clearly more simple to put it in a new building. Premises with joist and plank floors are not suitable for this kind of thermal storage heating. However, the Clean Air Act and the increasing demand from housewives for a simple form of domestic heating, have provided some encouragement for the development of a system of floor warming which could be readily installed in existing buildings with wooden floors.

In the prototype system which has been in use for the last two years in the old part of Wherstead Lodge (the building dates from 1793) the heating wires are laid on the existing wooden floor between strips of hardboard about 4 in wide. These cover the whole of the floor with gaps of ⅛ in between each strip and it is in these narrow gaps that the wires are laid. The wires are then held in position by another layer of hardboard, this time close-fitting. No staples or any other kind of fastener are used for the cable.

The room in which the system has been installed measures 12 ft 6 in by 11 ft, and the wiring is arranged in two circuits, having a capacity of 875 and 985 watts respectively. The maximum floor temperature aimed at is 75° F and as the wooden floor has little or no storage property the heating is switched on when it is required. There is an almost immediate sensation of warmth when the current is switched on, and the hardboard covering assists in the even distribution of the low intetnsiy radiant heat. The floor warming is used for background heating and is controlled by an energy regulator which can be adjusted at will by the occupants to suit their needs. An infra-red heater provides a focal point for "topping-up" if required.

It is believed that this installation is the first of its kind in this country and, while it is not claimed that there will ever be any great demand for the system, there should, nevertheless, be a limited use for it. It is suitable for offices and libraries as well as homes where a general background heating system is required. Carpets can be laid over the false hardboard floor and the surround can be polished to improve the finish.

NOISE IN FLATS *A Government Survey*

Noise disturbance in homes has been the subject of an extensive survey conducted over several years by the Department of Scientific and Industrial Research.

In their latest report,* the DSIR give a full account of a scientific investigation into the types of noise that cause discomfort and annoyance to people living in flats. Although the inquiry was confined to Local Authority flats the range of types investigated was large and, in principle, the results obtained are widely representative.

As well as actually measuring the various noises, the nuisance factor was evaluated by conducting a carefully planned survey through the media of written questionnaires and personal interviews. The survey is mainly sociological and does not attempt to recommend any form of standards for the sound proofing of buildings.

*Gray P. G., Cartwright, A., Parkin, P. H., *Noise in Three Groups of Flats with Different Floor Insulations.* (London: HM Stationery Office, 1958.) National Building Studies Research Paper No. 27.

PANELLED CEILINGS

A combination of hardboard and stillite, on a wooden frame, has been used by the Bowater Organisation, to produce panels with improved thermal and acoustic properties which may be used to replace the normal plaster ceiling.

The panels are 1 in thick and 2 ft square, built on a jig-made frame of seasoned softwood and surfaced with enamel painted hardboard. Several simple methods are available for fixing the panels in position. The facing is perforated to allow sounds to be soaked-up by the stillite, thus producing a considerable reduction of the noise level in the room. The thermal properties of the board arise from the fact that the stillite filling has a high thermal resistance—so preventing loss of heat by conduction. As well as minimising heat losses, there is less chance of moisture condensation on this type of material since its inner temperature tends to approach that of the room itself.

Further details may be obtained from Bowater House, Knightsbridge, London, S.W.1.

CONCRETE TILES

The use of concrete roofing tiles have shown a phenomenal increase of recent years. Since the war, the annual number of concrete roofing tiles produced in Great Britain has increased 40 fold, and from forming about one-sixth of the total production of tiles of any kind in this country, they now form four-fifths, and British methods of manufacture are being used all over the world.

Concrete roofing tiles were first made in Germany and samples can be found there that have given over a 100 years of service and are still in position; in Great Britain there are tiles over 50 years old which show no sign of deterioration. Well made, concrete tiles do not laminate under frost action and there is no reason why they should not be laid to give a sound waterproof covering. Many new designs have recently been introduced, and new methods of finishing now give a much improved degree of colour endurance, so that there need be little fear, it is claimed, of fading or discoloration.

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